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STUDY CONCERNING RAT-BITE FEVER IN MANILA, PHILIPPINE ISLANDS[1]

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[1] Presented for publication July 1, 1932.

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INTRODUCTION

It has been proved beyond doubt that rat-bite fever exists in Manila. The demonstration of the specific parasite that causes this disease in a patient, as reported by Ana Vazquez-Colet,[2] gave to the previous clinical reports sufficient weight to justify the statement that this disease has been endemic in Manila for many years. In view of the absence, in the past, of any systematic study of the conditions in Manila, with regard to rat-bite fever, the senior author projected a series of studies with the view of studying the biology of *Spirochæta morsus muris*, particularly with regard to its behavior in the body organism, immunity, hæmatology, transmission, and chemotherapy. Although these investigations have not exhausted the problem in all its details, the report, being the first of its kind that comes from Manila, gives a useful idea of the basic conditions existing at present in that city.

Besides the phases of the problem already mentioned, a comparative analysis was made between the distribution, throughout the City of Manila, of human rat-bite fever and that of plague, observed during the outbreak which occurred in Manila twenty years ago.

The senior author outlined the plan of the experiments, particularly those concerning the immunity as tested by superinfection and reinfection, as well as the chemotherapeutic experiments. The actual experiments on animals were carried out by Dr. H. Hirano, who has had a wide experience with this disease in Japan. The treatment of the two patients by specific drugs was given by Dr. Ana Vazquez-Colet, who is personally attending to the administration of antirabic treatment and who found all of the cases reporting at the Bureau of Science, making the diagnosis on clinical grounds and history. The isolation of the strains from the patients was carried out by Dr. H. Hirano. Thus the clinical diagnosis was confirmed.

[2] Philip. Journn. Sci. 46 (1931).

Dr. T. Corpus, of the Philippine Health Service, kindly assigned to us for study the cases that he encountered and diagnosed clinically in his health district. The hæmatological study on monkeys inoculated with rat-bite fever and that of one patient was carried out by Dr. José Ramirez. On his arrival in Manila, March 29, 1932, Dr. S. Arima continued the work of Dr. H. Hirano, who was recalled to his home country.

EXPERIMENTAL PROCEDURE

Unless mentioned otherwise the experimental animals were inoculated by intradermal inoculation. It was the purpose to produce a local lesion first, before the septicæmic stage set in, so as to approximate, in experimental animals, as much as possible the course of the disease as it occurs in man. Following the inoculation, the animals were inspected daily and their temperatures were recorded. Dark-field examinations were made at frequent intervals of time.

THE STRAINS OF SPIROCHÆTA MORSUS MURIS EMPLOYED

The strains employed in this study have been isolated by the authors from patients who acquired the disease in Manila. The first strain was obtained from a little Filipina, who had been bitten on the forehead by a rat at her residence in San Nicolas district in Manila.[3] This was the first case on record of rat-bite fever in the Philippines in which the etiology of the disease has been definitely proved through demonstration of the causative agent in the patient and in the experimental animals that were inoculated with the material obtained from the patient.

Shortly after this case was found by Doctor Vazquez among the patients applying at the Bureau of Science for preventive antirabic treatment, another case was found by Dr. T. Corpus, of the Philippine Health Service, in charge of the Meisic Health Station, Manila. The patient was sent to us for laboratory confirmation of his clinical diagnosis of rat-bite fever.

The patient was a young adult Filipino, a fireman by occupation, who resided in the same San Nicolas district as the first patient did. He exhibited typical local initial lesion on the finger and subsequent lesions on the arm as well as general manifestations of rat-bite fever.

[3] Vazquez-Colet, Ana, Philip. Journ. Sci. 46 (1931) 159–165.

The third case was found by Dr. Ana Vazquez-Colet among patients reporting for antirabic treatment at the Bureau of Science treatment station. It concerned a young Filipino man. (See stibosan in treatment of rat-bite fever, page 16.)

The fourth case was a 6-year-old Filipino boy in whom the clinical diagnosis was made by Dr. T. Corpus, of the Philippine Health Service. The doctor sent the patient to the Bureau of Science for laboratory confirmation of his clinical diagnosis, which was confirmed. The patient resided in Tondo.

The fifth case was a young son of an American residing in Paco district. The patient had been under treatment for some time before he was referred to us for laboratory diagnosis. (See stovarsol in treatment of rat-bite fever, page 13.) In a short time, one case in a small child residing in Quiapo district and two cases of adults residing in Intramuros, Manila, followed.

One more case was found in a child, in the vicinity of Tutuban Station. In March, 1932, another patient, a female adult suffering with rat-bite fever, reported for treatment. This case contracted the disease in Del Pan, a street that runs through San Nicolas district between the river and the bay shore.

May 12, 1932, a 50-year-old Filipina was sent to the Bureau of Science laboratory for Pasteur treatment. She had been bitten by a rat on the hand and exhibited typical primary and subsequent lesions as well as general symptoms of rat-bite fever. The patient contracted the disease at her residence, No. 322 Cabildo Street, Intramuros, more than two weeks previous to reporting for treatment.

SUMMARY

In the course of one year, 1931–1932, eleven strains of *Spirochæta morsus muris* were isolated from patients suffering with the disease and residing in Manila.

VIABILITY OF SPIROCHÆTA MORSUS MURIS

The experiments concerning the viability of *Spirochæta morsus muris* were arranged in such a way that measured quantities of blood of inoculated guinea pigs in which spirochætes were present, as demonstrated by the dark-field microscope, were diluted with sterile citrated salt solution and kept at various temperatures. From time to time, normal guinea pigs were inoculated with the salt-solution-blood mixture. After

several experiments in which we attempted to find out the proper amount of inoculum to be used, the experiment proper was performed and the results are shown in Table 1, page 47. From this table, it follows that under the conditions existing during the experiment, the spirochætes remained viable for at least eight hours, while in no instance were they found viable twenty-four hours or more after the blood has been removed from the infected animals. It may be seen also from the table that the temperature at which the infected blood was kept had no appreciable effect on the viability of the parasites in question.

CLINICAL MANIFESTATIONS OF RAT-BITE FEVER IN PHILIPPINE MONKEYS

The clinical picture of rat-bite fever varies in individual animals according to the severity of the infection and is largely dependent upon the mode of inoculation. A composed picture of clinical manifestations developed to a full extent in one and the same animal, what may be called "a classic case," consists of the following symptoms: (*a*) Initial local manifestation, (*b*) subsequent or regional dissemination of the infection, (*c*) general manifestations, (*d*) fever, and (*e*) exitus.

LOCAL MANIFESTATION OF RAT-BITE FEVER

A few days after intradermal inoculation of *Spirochæta morsus muris* the primary local lesion develops. Its intensity may vary to a certain extent, but it appears with great regularity and its incubation period is definite and quite constant. The first sign of the primary lesion is an elevated induration at the point of inoculation. It soon becomes surrounded by an œdematous area which gradually spreads, extending to the upper lid if inoculation was performed on the eyebrows. The œdema is at times so intense that a well-marked ptosis of the corresponding lid results. The œdematous swelling soon assumes a characteristic purplish blue tinge, which is particularly noticeable, even to an inexperienced eye, by comparing it with the white skin surrounding the eye of the Philippine monkey when unilateral inoculation into the eyebrow is practiced. The development of the primary lesion from the beginning to the full development lasts for some time. Regression starts in the center and rapidly spreads over the entire affected area. The œdema flattens and a more or less pronounced branny desquama-

tion and suggestion of alopecia are noticeable. The primary lesion heals without scars, and sooner or later during the development of the primary lesion, the original induration within the œdematous area, is found to be covered with a thin, slightly moist crust.

SUBSEQUENT OR REGIONAL DISSEMINATION OF THE INFECTION

A. LYMPHOGENIC OR REGIONAL METASTATIC LESIONS

(*a*) From the primary lesion the process spreads into the surrounding skin, following the lymphatic stream. Within the œdematous area new flat indurations form, which in turn become covered with a thin, slightly moist scab. This occurrence is not limited to the original œdematous area, that is to say to the eyebrow, but similar lesions spring up apart from the region of the original primary lesion. They may and frequently do form on the lower orbital margin, on the nose, or in the zygomatic region of the face. In such a case they represent flat, round, or oval indurations surrounded with a narrow œdematous area which is far smaller than that of the primary lesion. They, too, like the primary induration proper, become covered with a crust. The lesions under discussion are restricted to the side of the face on which the inoculation was performed, in other words they are not symmetric but unilateral, rarely crossing the middle line, which happens at times at the meeting point of the eyebrows.

(*b*) Frequently only slightly suggested, but at times pronounced, a diffuse purplish blue exanthema in the face or on the anterior surface of the neck was observed. This exanthema is located apart from the lesions just described, is most pronounced in the central part of the affected skin area, and gradually vanishes into the normal skin. This exanthema is more evanescent than the lesions described above.

(*c*) Regional lymphadenitis is encountered at times to such a degree that the lymph nodes are distinctly enlarged on palpation, while at other times, though palpable, it is difficult to ascertain definitely their enlarged condition by mere palpation.

GENERAL MANIFESTATIONS

Of the general symptoms of rat-bite fever in Philippine monkeys, the following were noted: (*a*) Fever, (*b*) general lymphadenitis, and (*c*) diarrhœa.

Fever.—The fever observed in Philippine monkeys that were infected with *Spirochæta morsus muris* by intradermal injection is of the remittent type. Soon after the inoculation, the temperature shows a slight rise followed by a drop. The temperature curve remits, climbing to the highest peak usually on the ninth day after intradermal inoculation, after which day the temperature gradually declines, following the remittent type. Before it reaches normal it shows several elevations, preserving the general type of remittent fever. In case of a lethal infection, the temperature crosses the normal line and continues dropping for several days before exitus.

General lymphadenitis.—In a few monkeys infected with rat-bite fever distinct, palpable, lymph nodes were noted in parts of the body remote from the point of inoculation in animals in which glands were found normal at the beginning of the experiments.

Diarrhœa.—Not infrequently during experiments with rat-bite fever on Philippine monkeys, as a symptom of general infection, distinct diarrhœa was observed. Its occurrence in the course of the infection coincides with the febrile stage. It was usually of catarrhal character, but frequently a considerable amount of mucus and blood was observed. This observation was supported by the autopsy findings. Without exception, hyperæmia of the intestines and enteritis of the septicæmic type were encountered post mortem.

CLINICAL MANIFESTATIONS OF RAT-BITE FEVER IN GUINEA PIGS AND RABBITS

THE INITIAL AND SUBSEQUENT SKIN LESIONS IN GUINEA PIGS AND RABBITS

As in monkeys, so in guinea pigs and rabbits, the initial and the subsequent lesions were typical. The initial lesion was characterized by soft swelling, a papular efflorescence. It increased in size and spread on the periphery. As in yaws it commenced to heal and flatten in the center. When the initial lesion reached a certain size there developed a desquamation on the surface of the lesion and the formation of scabs. Rarely an ulcerative lesion formed in the center of the initial lesion.

The subsequent lesions sprang up around the initial lesion. They were much smaller than the initial lesion and more superficial, showing a good deal of desquamation and frequently were covered with superficial dry scabs.

Of the general lesions, alopecia, lymphadenitis, fever, desquamative blepharitis, and even an inflammation of conjunctiva and cornea were observed. These were late lesions, and spirochætes were not found in them. They healed on specific treatment and were coincident with the general atrophy of the experimental animal's body. The variety of lesions experimentally produced by inoculations with rat-bite fever makes guinea pigs and rabbits desirable animals for experimental study of this infection. We have noticed no advantage, in this respect, of the monkey as an experimental animal over the guinea pig or the rabbit.

THE INVASION OF THE BLOOD STREAM BY SPIROCHÆTA MORSUS MURIS IN PHILIPPINE MONKEYS

The invasion of the blood stream by spirochætes in the Philippine monkey appears to be intermittent. The number of spirochætes in the circulating blood at any time was very small. In no case was it possible to detect the presence of spirochætes in the circulating blood by repeated and thorough dark-field microscope examinations. In order to demonstrate the parasites in the circulating blood, inoculation of guinea pigs and white mice with the blood of infected Philippine monkeys had to be resorted to. Following this procedure, which may be termed an enrichment process, we were able to demonstrate the fact that *Spirochæta morsus muris* invades the blood stream of Philippine monkeys. The majority of the monkeys were inoculated only once, while two of them (Syp–25 and J–11) had been superinfected and samples of blood were used to inoculated guinea pigs and mice. It was found that the blood of monkeys that were bled during the early period of infection harbored at times demonstrable spirochætes. In monkeys in which the infection had lasted for a long time, the specific parasites could not be found in the blood stream. In this particular experiment the dividing line was about sixty-nine days in a superinfected animal. Below this time limit and including the sixty-nine days, the spirochætes were demonstrated to be present six times in nineteen trials. Samples obtained from monkeys that had been infected for more than sixty-nine days, that is to say in seven instances, the transfers of blood to susceptible animals were invariably negative.

It follows from these findings that in Philippine monkeys the spirochætes invade the blood intermittently during the early

stage of the infection and that after the infection has lasted for some time, in our case about two months, they no longer can be demonstrated in the blood stream.

THE INVASION OF THE BLOOD STREAM BY SPIROCHÆTA MORSUS MURIS IN GUINEA PIGS

In guinea pigs the study of this manifestation of rat-bite fever infection can be more easily pursued than in monkeys, since the parasites occur in the circulation of guinea pigs in sufficient numbers to be detected microscopically. Thus, the study becomes technically simple, particularly when a dark-field microscope is used.

The time between the intradermal or subcutaneous inoculation by viable and virulent spirochætes and their first occurrence in the circulating blood averaged, in our experiments, seventeen to eighteen days. Eight days was the shortest, and thirty-nine days the longest, time that elapsed between the inoculation and the appearance of the parasites in the blood of these experimental animals. The occurrence of the spirochætes in the blood stream is intermittent, and the number of them encountered at various times is variable. If the animal succumbs to the infection in the very acute stage, they persist in the blood stream to death. In those instances where infected guinea pigs survived the acute stage, the periods of negative findings separated by positive findings became longer the longer the animals lived. Thus the phenomenon of gradual disappearances of the spirochætes from the blood stream in the course of the infection that was indicated in the findings on monkeys is more pronounced in the case of guinea pigs.

CHEMOTHERAPEUTIC EXPERIMENTS WITH PHILIPPINE STRAINS OF SPIROCHÆTA MORSUS MURIS

In a publication in which P. Uhlenhuth and V. Seiffert[4] discuss the results of recent studies along the lines of experimental antimony therapy, the following statement is found: "Of particular significance, however, is the specificity which is observed again and again in experiments with various antimony-preparations." And further: "Only an experimental investigation arranged in many directions can discover the specific efficacy of chemotherapeutics."

[4] Klin. Wochenschr. 10 (1931) 1755.

We have felt, likewise, that further experimentation on chemotherapy is highly desirable and the above statements, coming from such a competent source, have encouraged us to publish the results of our experiments with regard to the chemotherapy of rat-bite fever. This is done in particular for the reason that the Philippine strains have not been studied hitherto, and although other experimental results point to the expectation that, as in other respects, in chemotherapy the Philippine strains will behave in very much the same way as do other strains of this particular spirochæte, experimental evidence is always reassuring and not out of place.

Our chemotherapeutic experiments concern guinea pigs, rabbits, and Philippine monkeys. Of the arsenicals, neosalvarsan and stovarsol were used. Antimony was represented by antimosan, stibenyl, and stibosan. Bismuth was used in the form of quinine-iodo-bismuthate, mercury as mercury salicylate. The chemotherapeutics concerned were tried partly as treatment of already infected animals, partly as preventatives; that is, the drugs were administered before the disease broke out in experimentally inoculated animals.

EXPERIMENTS CONCERNING CHEMOTHERAPY OF RAT-BITE FEVER

Guinea pigs of approximately the same weight were inoculated with a Manila strain of rat-bite fever. The spirochætes were found repeatedly in the blood of the inoculated animals. Thus we were assured that the inoculation resulted in a successful infection. The animals were then treated with the various drugs, and the blood examination by means of the dark-field microscope and stained slides was continued. Two drugs used in these experiments gave satisfactory results.

Neosalvarsan, the effect of which upon *Spirochæta morsus muris* is well established, gave undoubtedly the best results. In successfully infected animals that were treated with neosalvarsan, the spirochætes disappeared from the blood stream. The examinations were made from the third to the thirtieth day after the treatment. Stibosan is another drug that showed marked effect.

Using the other drugs—that is, quinine-iodine-bismuthate, antimosan, and mercury salicylate—the results were doubtful. Likewise, stibenyl showed no effect upon the spirochætes in the blood stream; on the contrary, not infrequently, a striking in-

crease of spirochætes in the blood stream of animals treated with this drug was noticed.

Taking the excellent effect of neosalvarsan upon the rat-bite fever infection as well established, we have extended our experiments with stibosan in search of further information with regard to its effect on rat-bite infection.

The effect of drug treatment on the temperature curve of guinea pigs infected with rat-bite fever was quite evident. Not only those drugs that brought about permanent disappearance of the spirochætes from the circulating blood but also some of those that failed to do so showed an effect on the temperature curve in the same direction. The immediate effect is a sudden drop of temperature. This drop may be very abrupt as can be seen in M–22 (neosalvarsan) and in M–32 (stibosan). The higher the fever, previous to treatment, the deeper appears to be the dip of the temperature curve. It sometimes drops below normal and suddenly returns only to continue, at a lower grade, the same type of curve that it did before treatment. A slightly pronounced, but similar effect was noticed when treatment with bismuth (M–36) and even with mercury (M–46) was given. This phenomenon—that is, the drop in the temperature curve, was found constantly only in those animals that, having been infected, were treated particularly with either neosalvarsan or stibosan. An effect similar to that of successful chemotherapy on the temperature curve can be seen in the animals that were treated when relapse occurred or reinfection was performed.

This effect of the drugs concerned upon the drop of body temperature was absent when the drugs were injected to normal healthy animals of the same kind.

EXPERIMENTS CONCERNING PREVENTIVE CHEMOTHERAPY OF RAT-BITE FEVER

The experiments were arranged in such a way that the animals, when infected, received at the same time one intramuscular injection of the respective drug in an appropriate amount. No further treatment, aside from the first injection, was given. The animals were approximately of the same body weight, from 270 to 370 grams. The animals were kept under observation for three months, and daily examinations for spirochætes were made. With each group inoculated, one normal, untreated guinea pig was also infected and served as a control of viability of the inoculum.

From this experiment, which completes the preceding one, it follows that of the drugs tested (mercury salicylate, stibenyl, antimosan, quinine-iodide bismuthate, and stibosan) stibosan was the only one that showed marked effect as a preventative against rat-bite fever infection.

In view of the high efficacy of stibosan towards *Spirochæta morsus muris*, as a therapeutic and preventative, an experiment was arranged in which stibosan in measured dosage was given intramuscularly and infection was performed sometime later. It was desired to know, approximately, how long the protective power of the stibosan injection would last in guinea pigs. It was found that the preventive protection of stibosan against rat-bite fever lasts between two and three weeks, depending on the dose of the drug per unit of body weight.

DISCUSSION

In an extensive work on the chemotherapy of rat-bite fever in white mice, Schlossberger [5] enumerated a long series of drugs that gave negative results. Among others, the author mentioned antimosan, stibenyl, and stibosan. He claimed that complete sterilization of mice was only obtained by the use of arsenicals; such as, stovarsol, sulpho, and neosalvarsan. Our results of experiments agree with those of Schlossberger with regard to antimosan and stibenyl; however, stibosan gave at our hands promising results.

On the other hand Schockaert [6] claims that stibosan gave satisfactory results in his experiments with rat-bite fever. These differences of findings may be due to the fact that different experimental animals may have been used or that the strains of *Spirochæta morsus muris* employed by various authors showed differences in their susceptibility to this drug. It may also be mentioned that stibosan must be used in freshly prepared solutions in order to give the desired effect on the particular spirochætes. If the solution of stibosan is allowed to stand at room temperature for twenty-four hours or if it is heated, the effect of the drug may become equal to that of stibenyl; that is to say, nil. It may be well to remember that the difference

[5] Ztschr. f. Hyg. u. Infectionskrankh. No. 4 108 (1928) 627–636, July 3.

[6] Antimontherapie im Rattenbissfieber. [Antimony treatment in rat-bite fever.] Deutsche Med. Woch. 57 (January, 1931) 103–104. (16 refs.) (Bact. Inst., Univ. Lowen.)

in the chemical composition of stibosan and of stibenyl consists in the presence of one chlorine in stibosan. Our experiments with stibosan, on sixteen guinea pigs that survived long enough after the treatment to allow conclusions, invariably gave satisfactory results. That is to say, in guinea pigs the spirochætes, which were found in the blood of the animals previous to the treatment, could not be demonstrated there after one injection of stibosan and the animals lived.

These therapeutic results with stibosan have been confirmed by the results of preventive therapy of rat-bite fever with the same drug.

A HUMAN CASE OF RAT-BITE FEVER TREATED WITH STOVARSOL

The use of arsenical preparations in the therapy of human rat-bite fever is well founded. That the Philippine strains of *Spirochæta morsus muris* are amenable to the effect of arsenicals is evident from the early publications of Guerrero and Montes as well as from the recent observations made by Dr. Ana Vazquez-Colet.

It may be desirable at times on the part of the physician or on the part of the patient to avoid injections, in which case arsenicals administered by mouth must be considered. It was, therefore, attempted to find out the possibilities of this kind of treatment in chemotherapy of human rat-bite fever. One case treated with stovarsol is reported herewith.

HISTORY

November 16, 1931.—E. Laird, 13 years old, male, residing at 21 Mindoro, Paco, Manila. About two months ago woke up in the morning and felt pain over the right eyebrow. He noticed on the right eyebrow a bite the size of a pin prick. Some time later the place of bite became sore. The patient scratched the sore place, and a swelling developed. The next day the swelling extended also on the opposite eyebrow. It persisted until the present time. The patient entered St. Paul's Hospital Oct. 9, 1931, and was discharged Oct. 14, 1931. He returned to the same hospital Nov. 4, 1931, and was discharged Nov. 11, 1931. The patient was treated by hot compresses applied to the lesion. While in the hospital the patient was taking some liquid medicine by mouth. Each time the patient stayed in the hospital the lesion improved under treatment.

Present condition.—The patient weighs 37.2 kilograms. Temperature by mouth 37.6° C. at 11.00 a. m. Pulse 120. General condition good. On the left half of the face there is a distinct swelling surrounding the left eye completely and partially closing the left eye. The swelling is spreading over the left cheek. The preauricular region is distinctly elevated, and there is a considerable swelling under the ear in front of the

upper insertion of the sternocleidomastoid muscle, gradually diminishing down towards the clavicle, but it is still noticeable in the supraclavicular region. In the swollen region there are palpable superficial lymph nodes, hard and large, following the anterior margin of the muscle. Small lymph nodes are perceptible on the posterior margin of the muscle. Nothing abnormal in the axillæ and plica cubiti. Patient complains at present of no pain. The affected parts are firm to the touch and show a pinkish discoloration of the skin contrasting with the light complexion of the rest of the face. On the upper margin of the left forehead, near the hair line, there is a conspicuous, elevated, rather red, lymphangitic, wavy line about 2.5 cm long and 2 mm wide, and in the space between the eyebrows there is a distinct, pink, maplike, slightly elevated maculo-papulous efflorescence about 1 cm in diameter. Under the outer half of the left eyebrow there is a distinctly palpable induration of the skin about 1 cm. by 0.5 cm.

November 17, 1931, 3 p. m.—Temperature by mouth 38.6° C. One-half tablet stovarsol, dissolved in a small quantity of water, was administered by mouth. Leucocyte and differential counts were made by Ramirez (postea). Urine findings normal.

The left upper and lower eyelids have acquired a purplish discoloration. A rounded, pink, papulo-macule, about 0.75 cm in diameter has developed on the right cheek by the nostril which is quite firm to the touch. Papulo-macules about 0.5 cm in diameter have also appeared below and behind the left ear. A maplike area, about 2 by 1 cm, delineated by a fine lymphangitic line, has appeared on the left side of the back of the neck. The lymphangitic line on the forehead still persists, being slightly redder and wider than before. The posterior, superior, cervical, lymphatic glands are swollen.

Tissue scrappings were obtained from an incision made into one of the maculo-papules and typical spirochætes were found in smears stained by Giemsa's method.

November 18, 1931.—The patient was seen at his home because of high fever. Temperature by mouth 40.1° C. Pulse 122. Urine normal.

Left eye is closed and the affected parts are swollen and intensely red. The papule on the right cheek and the one between the eyebrows, below and behind the left ear, persist and are firm to the touch. The upper eyelid is indurated. The superficial cervical glands are greatly swollen and hard. The posterior cervical glands are swollen. A lymphangitic line about 2 mm wide and irregular in its course, extends from the middle of the left lower lid, down the neck, to the left clavicle. Reddish blotches are present, here and there, on the left lateral and posterior portions of the neck. The lymphangitic line on the forehead, described previously, is not visible now, but another one has appeared on the scalp, following the hair line on the left forehead and temple. Over the affected parts of the skin, which is now intensely red, small irregularly shaped patches of light skin are visible. The rest of the body shows nothing abnormal.

November 19, 1931, 2.30 p. m.—Patient came to the Bureau of Science. Temperature by mouth 37.4° C. Pulse 97. All the redness has gone, except on the left upper eyelid. This eyelid, especially towards the eyebrow,

is indurated. The left eye still appears much smaller than the right one. The swelling of the glands has greatly subsided. No reddish blotches, no lymphangitic lines are visible anywhere. The papules on the right cheek, which were visible yesterday between the eyebrows and below and behind the left ear, have disappeared. The patient says that he feels well and strong to-day, while yesterday he was feeling weak and could hardly stand. He reports that yesterday he continued to sweat profusely, after which he was free from fever. The patient was given by mouth one tablet stovarsol dissolved in water. Urine was found normal. Leucocyte and differential counts were made by Ramirez (postea).

November 20, 1931, 2.30 p. m.—Temperature by mouth 37.2° C. The upper eyelid is now much less swollen, showing a faded brownish purplish color. The induration is greatly reduced and the eye can now be opened wider than before. The glands on the neck have all greatly subsided. The patient is feeling well. One and one-half tablets of stovarsol were administered to the patient.

November 21, 1931, 11 a. m.—Temperature 37.4° C. Brownish purplish discoloration still persists on the left upper eyelid, though the induration has greatly regressed and the patient can open the affected eye wider than yesterday. The glands continue subsiding, though the superior cervical glands still show slight bulging of the neck. One and one-half tablets of stovarsol administered.

November 23, 1931, 2.45 p. m.—Temperature 37.2° C. Brownish purplish discoloration still persists, under the left eyebrow the induration is greatly reduced. The swelling of the glands is reduced, the superior cervical glands no longer bulging out. The anterior auricular gland is still palpable, this region being elevated as compared with the right side. One and one-half tablets of stovarsol administered.

November 24, 1931, 2.30 p. m.—Temperature 37.2° C. No appreciable change from yesterday is detectable, save perhaps that the left eye is somewhat more opened than before. Two tablets of stovarsol administered.

November 25, 1931, 2.45 p. m.—Temperature 37.5° C. Only a slight induration is detectable under the left eyebrow, the left upper eyelid is still reddish brown. Glands still palpable on the affected side of the neck. The left anterior auricular gland has softened somewhat, but this region is still elevated. The same may be said of the superior cervical glands on the left side. Two tablets of stovarsol administered.

November 27, 1931, 2.45 p. m.—Temperature 37.5 ° C. Practically no change in the local symptoms is noticeable except that the left anterior auricular and the posterior cervical gland have further regressed. Two tablets of stovarsol administered.

November 28, 1931, 11.30 a. m.—Temperature 37.4° C. No change from yesterday. Two and one-fourth tablets of stovarsol administered.

December 1, 1931, 3.50 p. m.—Temperature 37.5° C. The discoloration of the left upper eyelid has further regressed, though it is still noticeable at a distance. The left eye is still smaller than the right eye. The glands have regressed in size, the left anterior auricular being quite soft now. No medicine was administered this day.

December 4, 1931, 1.55 p. m.—Temperature 37.5° C. The discoloration of the upper eyelid considerably regressed, but it is still noticeable at a

distance. The left eye is now only slightly smaller than the right eye. The glands smaller, particularly the left anterior auricular lymph nodes are smaller. No medicine was administered to-day.

December 8, 1931, 1.45 p. m.—Temperature 37.6° C. The left anterior auricular gland is larger now than it was yesterday, otherwise no change from yesterday. Two tablets of stovarsol administered.

December 9, 1931, 1.35 p. m.—Temperature 37.7° C. Same as yesterday. Patient dismissed.

SUMMARY

One case of human rat-bite fever of about two months duration was treated with stovarsol.

CONCLUSION

Stovarsol and allied preparations may be effective drugs in the treatment of human rat-bite fever.

A HUMAN CASE OF RAT-BITE FEVER TREATED WITH STIBOSAN

Stibosan having been found effective among the drugs that were tested on animals, it was desired to treat a human case of rat-bite fever with this drug in order to find out its possibilities in the chemotherapy of human rat-bite fever.

HISTORY AND COURSE OF THE DISEASE

October 27, 1931, 2.40 p. m.—Simeon Rasonable, 22 years old, male, while sleeping at 69 Padre Rada, Tondo, was bitten on the dorsal side of the left hand at the root of the middle finger, about 3 a. m. two weeks ago. An area surrounding the site of the bite, about 1 inch in diameter, presents an indurated red swelling, which according to the patient developed two days ago. There are three small scars visible on this area at the insertion of the middle finger, just below the knuckle. Lymphatic glands at the elbow are swollen, tender, and painful. Temperature by mouth 37.4°C.

Wassermann and Kahn tests were negative. The patient was given an intramuscular injection of 0.2 g of stibosan into the left buttock.

October 28, 1931, 3 p. m.—Temperature 37.6° C. The patient states that the pain in the hand, elbow, and axilla has diminished. He slept well last night. He also reports that he felt very weak after the injection of stibosan.

The redness on the hand extends up to the wrist now and down the little finger, involving about two-thirds of the proximal portion of the said finger. The swelling consists of a firm indurated œdema.

Smears were prepared from aspirated gland juice from one of the enlarge elbow glands. No spirochæte found.

October 30, 1931, 3.30 p. m.—Temperature 38.2° C. The redness and swelling are greatly reduced, and the induration has greatly diminished. The redness is limited to the upper third of the middle finger and to the corresponding knuckle. Above this the skin is of a dusky purplish color.

Patient reports that he had fever ever since October 28, 1931, and that he could not sleep last night. The pain in the cubital and axillary region persists. The patient was given an intramuscular injection of 0.2 g of stibosan.

October 31, 1931, 10 a. m.—Temperature 37.8° C. The patient reports that he was able to sleep well last night but that the hand was painful, the pain persisting even now. The epitrochlear and axillary glands are tender. The area of redness has subsided, though the swelling (œdema) has increased. The induration has further diminished. A dusky purplish discoloration of the skin over and around the site of bite still persists. The patient was given an intramuscular injection of 0.2 g of stibosan. A few moments after the injection, the patient vomited.

November 2, 1931, 3 p. m.—Temperature 38.2° C. The œdema is greatly reduced, being confined to the upper fourth of the middle finger and to the corresponding knuckle. The lymphatic glands are reduced in size and are much less tender. The patient reports that he sleeps well these days. An intramuscular injection of 0.2 g of stibosan was given. Five minutes after the injection, the patient asked to be allowed to go home because he felt very sleepy.

November 3, 1931, 2.30 p. m.—Temperature 37.6° C. The œdema has further subsided, and the redness has disappeared. The area of the bite shows a brownish dark discoloration contrasting markedly with the clear brown color of the normal hand. Tenderness of the glands has disappeared, and they are reduced in size. The patient reports that he feels well.

November 4, 1931, 2.30 p. m.—Temperature 37.0° C. The portion of the epidermis at the site of bite about 2 cm long by 1.5 cm wide is desquamating covered with slightly pinkish new skin. The œdema is further reduced as well as the discoloration. The glands are still palpable but not tender. Slight induration still present at the site of the bite. The sites of the injections of stibosan are indurated and tender. The patient states that he feels well. Intramuscular injection of stibosan was administered.

November 5, 1931, 3.20 p. m.—Temperature 37.3° C. The œdema has further diminished, and the desquamation continues. The patient reports that he did not feel sleepy yesterday after the injection and that he did not vomit. Wassermann negative; Kahn ±.

November 6, 1931.—Temperature 37.0° C. No œdema is detectable. The dark brown discoloration (pigmentation) persists. Desquamation has not progressed. Induration still appreciable. The glands at the elbow and axilla are greatly reduced in size, and they are no longer tender.

November 9, 1931, 3 p. m.—Temperature 37.0° C. Desquamation has advanced around the site of bite. Pigmentation as well as induration still persists.

November 11, 1931, 3.20 p. m.—Temperature 37.2° C. No appreciable change in local symptoms.

November 16, 1931, 3.30 p. m.—Temperature 37.3° C. No appreciable change except some more desquamation is noticeable. Pigmentation and induration still present. Glands greatly reduced, not tender. The patient was dismissed as cured and requested to report every Monday, or earlier in case he should develop headache or fever.

November 20, 1931, 3.30 p. m.—Temperature 37.7° C. The patient reports that he had fever November 18, 1931, from 9 p. m. to 3 a. m. the next morning and November 19, 1931, during the same hours. This morning when he woke up he felt pain in the lower internal part of the left thigh and could not stand up for about half an hour. A small painful and indurated efflorescence about the size of a small pea is palpable in this region. The patient was given an intramuscular injection of 0.2 g of stibosan.

November 21, 1931, 11 a. m.—Temperature 37.0° C. The patient reports that he was greatly alarmed yesterday because of an urticarial rash, which suddenly cropped up over his whole body. He shows indurated flat papules, not disappearing on pressure, on the left forearm (extensor surface); on the right leg (internal surface). The patient states that yesterday he felt pain in the right thigh. The pain in the left thigh still persists.

November 23, 1931, 3.30 p. m.—Temperature 37.2° C. The papules on the left forearm and the right leg still persist. They are indurated and red. Those on the left forearm are small, measuring from 0.5 to 3 mm in diameter. Those on the leg are rather large, about 2 cm in diameter on the surface of the skin, surrounded by deep induration. The tenderness is still present on the lower internal portion of the left thigh. There is also tenderness of the epitrochlear lymphatic glands. Tissue scrappings from one papule on the forearm and from one on the leg were prepared, to be examined for spirochætes. The tissue scrappings from the leg shows typical spirochætes in smears stained by Giemsa's method. The patient looks pale and sick and is rather weak. Wassermann ±; Kahn negative.

November 24, 1931, 3 p. m.—Temperature 37.1° C. The papules still persist but are slightly less indurated, being now less elevated than before. Two large lymphatic glands above the elbow are palpable; one is tender. Tenderness in the lower internal part of the thigh persists.

November 25, 1931, 3 p. m.—Temperature 37.4° C. Some of the papules that were present on the left forearm have disappeared, while others have flattened out. The papules on the right leg are without change; they are painful and tender.

November 27, 1931, 2.15 p. m.—Temperature 37.1° C. The papules have further flattened and have acquired a dusky purplish discoloration. The lymphatic glands above the left elbow are greatly reduced in size and are no longer tender. One tablet of stovarsol dissolved in water was administered to the patient by mouth.

November 28, 1931, 10.30 a. m.—Temperature 36.7° C. The lymphatic glands above the left elbow are soft and smaller. The lesions on the right leg have softened greatly and their purplish discoloration has almost disappeared. The papules on the left forearm have faded away, only three small ones are still to be discerned by their purplish discoloration.

December 1, 1931, 3.30 p. m.—Temperature 37.0° C. Small brownish macules are still to be seen at the sites of the former papules on the left forearm. One of the large papules on the leg has disappeared, and only a slight induration marks its site. The other one has softened and the skin over it is darkly pigmented. The lymphatic glands above the left elbow are reduced in size and are now the size of small beans. The patient

states that he feels well. Pigmentation at the site of the bite is very slight, and only a very slight induration is detectable.

December 2, 1931, 3.20 p. m.—Temperature 36.5° C. The macules on the left forearm are fading away, being smaller and not so conspicuous as yesterday. The induration on the right leg is further reduced in size and hardness, and the skin over it is desquamating. No change observed in the left epitrochlear glands.

December 3, 1931, 3 p. m.—Temperature 36.9° C. The macules on the left forearm have faded, and the glands above the left elbow are smaller and softer than they were at the last inspection. The induration on the right leg is reduced to a pigmentation; desquamation persists. The patient believes himself cured and wishes to discontinue treatment.

December 4, 1931, 3 p. m.—Temperature 37.0° C. Several macules on the left forearm have disappeared, and those remaining have so faded and are so reduced in size as to be almost invisible. The induration on the right leg and the lymphatic glands above the left elbow show no change. The patient reports that he had diarrhœa last night. One tablet of stovarsol given by mouth.

December 5, 1931, 11.30 a. m.—Temperature 37.1° C. The macules on the left forearm have further faded. Induration on the right leg has diminished.

December 7, 1931.—Temperature 37.1° C. One tablet of stovarsol administered.

December 8, 1931, 2.15 p. m.—Temperature 36.9° C. The pigmented macules on the left forearm are hardly visible now. Only a slight induration remains on the right leg, the desquamation at that site having further regressed. One tablet of stovarsol given by mouth.

December 9, 1931, 3.30 p. m.—Temperature 37.1° C. The pigmented macules are no more to be seen. Induration on the right leg and the desquamation have ceased. Patient dismissed.

SUMMARY

A case is reported of rat-bite fever in a patient who has been treated with stibosan. The beneficial effect of this drug on the course of the disease is clearly evident. The patient, apparently cured, developed a relapse at the place of primary lesion. At the same time, subsequent specific lesions developed at the places remote from that of the primary lesion. The treatment was resumed and terminated successfully by administration of stovarsol.

CONCLUSION

Stibosan was found to be a useful drug in the treatment of a human case of rat-bite fever. It may be particularly useful in cases in which vigorous arsenical treatment is contraindicated or as an adjunct treatment in combination with arsenicals.

THE BLOOD PICTURE IN EXPERIMENTAL RAT-BITE FEVER IN PHILIPPINE MONKEYS

TECHNIC

All the blood samples were taken at about the same hour of the day, early in the morning before feeding the animals.

One of the fingers of an upper extremity, preferably the thumb, was cleansed with alcohol and allowed to dry, then a deep puncture was made with a needle. The first drop of blood was discarded, subsequent ones being used for the blood pipettes and the smears.

For the total count an ordinary hæmocytometer white-cell pipette was used. Having a fairly large drop of blood, the tip of the pipette was applied to it and the blood carefully drawn up to the 0.5 mark. Then the diluting fluid (1 per cent solution of acetic acid) was drawn up to the mark 11. After mixing thoroughly by shaking, the fluid below the bulb was expelled and a fairly large drop was deposited in the edge under the cover slip of the Neubauer double-ruling counting chamber. Two counts were made each time and the average recorded.

For the differential count two absolutely clean and grease-free slides were used. A small drop of blood was taken on the slide on which the smear was to be made, at about 0.5 inch from one end; one of the edges of the "spreader-slide" was placed on the drop, and as soon as the blood ran along the edge, the spreader was drawn along with an even sweep to the other end of the slide, and a thin smear was obtained. After being thoroughly dried this was stained with Wright's stain.

In making the differential count we classified the cells in every other row across the slide, the edges always being included, and from 300 to 500 cells were counted each time.

The cells were differentiated according to the Schilling Torgau's classification, as follows:

- Basophiles.
- Eosinophiles.
- Neutrophiles.
  - Myelocytes.
  - Metamyelocytes.
  - Staff nucleated.
  - Segment nucleated.
- Lymphocytes.
- Large mononuclears.

After taking the blood samples, the temperature was obtained in the anus with a clinical thermometer, and the appearance of the lesions and other symptoms were noted.

In the human case (R. Laird) R–B (E. L.) samples were taken usually in the afternoon. The temperature was taken by mouth. The blood samples were taken from the patient's fingers, the technic being the same as that used in the case of monkeys.

DISCUSSION OF HÆMATOLOGIC FINDINGS

The total leucocyte count, in the course of artificial rat-bite fever infection in Philippine monkeys, varies considerably from day to day. When the daily counts were plotted in a curve, certain regularities in the behavior of the leucocytes became evident as well as the relation between the reaction on the part of the leucocytes and the other clinical phenomena concomitant to the course of the infection became known. From the attached charts (Plates 4 to 10) it is evident that the rise and the drop in the total leucocyte count is parallel to the rise and drop in the temperature curve. While in the early part of the curve the shifting of the leucocytes is synchronic, in the later part the excursions of the leucocyte curve appear slightly behind those of the temperature curve. Repeated attacks as they occur in the course of experimental rat-bite infection and which are discernible in the periodic elevations of temperature and, as mentioned before, in the periodic exacerbations of the skin lesions that go hand in hand with the invasion by the parasites of the blood stream are clearly evident in the leucocyte-count curve. Thus, the typical attack in rat-bite fever is characterized, as far as the blood picture is concerned, by leucocytosis. The differential count that is plotted on the lower part of the charts gives further information as to the kind of leucocytes involved in the periodic shifting of the blood picture. It can be seen that each individual attack is expressed by an increase of polymorphonuclears and simultaneous drop in lymphocytes. Of the other leucocytes, the staff-nucleated cells are somewhat increased coincidently with the rise of polymorphonuclears and there is a steady upward increase of the staff cells in the course of experimental rat-bite fever. The mononuclears, on the other hand, follow a curve parallel to the lymphocytes. The rest of the leucocytes show only insignificant changes.

Towards the end of a fatal experimental rat-bite fever infection, there is a considerable increase in total leucocytes, staff cells, and, at times, lymphocytes and mononuclears. Immediately before exitus and when the temperature plunges downward, all the leucocytes may show a downward drop. The clear indication of individual attacks as reflected in the blood picture—that is, a wide separation of the polymorphonuclear and lymphocyte curves—is best evident in the charts for R–B–10 and R–B–14 (Plates 7 and 9).

THE EFFECT OF SPECIFIC TREATMENT ON THE BLOOD PICTURE IN RAT-BITE FEVER

The effect of specific treatment on the blood picture in rat-bite fever is best evident in monkeys R–B–8 and R–B–9 (Plates 5 and 6). The animals had been inoculated with a Manila strain of *Spirochæta morsus muris*, and the disease was allowed to run its course for seventy days. Typical initial lesions and a characteristic temperature curve, as well as leucocytosis, were observed in the course of the first seventy days. Several distinct attacks, as indicated by the elevation of the temperature curve and the leucocyte reaction, were observed in the course of this period of time. Seventy days after inoculation, 0.015 gram of neosalvarsan was injected intramuscularly to both of these animals. In one case a striking increase of leucocytes was noticed, after which the leucocyte curves show a tendency to return to normal. The excursions of the curves are more moderate and the periods of the separation of the polymorphonuclear and the lymphocyte curves are shorter than before. The staff cells that had risen perceptibly during the first seventy days of infection returned practically to normal following the one injection of neosalvarsan. The ninety-ninth day of the infection, 0.04 gram of stibosan was injected to both animals, intramuscularly. The leucocyte curve following this injection shows a further tendency to return to normal until the terminal rise of the total leucocyte count set in, which was due to an increase of polymorphonuclears.

THE EFFECT OF REINFECTION WITH RAT-BITE FEVER ON THE BLOOD PICTURE IN AN INFECTED AND TREATED PHILIPPINE MONKEY

One of the two monkeys that had been infected with rat-bite fever and treated was subsequently reinoculated intradermally with the same strain of *Spirochæta morsus muris* one hundred twenty-one days after the original inoculation. Within the brief time that the animal survived, following the

reinfection, the blood picture again showed the same leucocyte reaction as was observed on the same animal when first inoculated. The terminal leucocyte reaction was of the same type as observed in untreated single-inoculated Philippine monkeys.

CONCLUSION

A characteristic leucocytic reaction accompanies an attack of rat-bite fever. The reaction consists of leucocytosis, due mainly to an increase of polymorphonuclears but also to the increase of staff-nucleated leucocytes and concomitant lymphocytopenia.

The leucocytic reaction is synchronic with the elevations of temperature. This shifting of leucocytes disappears some time after treatment, but reappears upon reinfection following treatment.

HÆMATOLOGIC OBSERVATION ON A HUMAN CASE OF RAT-BITE FEVER

In order to illustrate the similarity between the blood picture in human rat-bite fever and that encountered in experimental inoculated Philippine monkeys, the temperature chart of a human case is included (Plate 4). The details of this human case are recorded on page 13. The curve given in this chart was constructed from individual counts made at frequent intervals, and the similarity of the curves registering the total count, as well as the differential counts, with those of the infected monkeys is at once evident. The next day after the first count was made the treatment began. Following the first treatment the temperature rose and, coincidently, a rise in leucocytosis is apparent; the latter is due to increased polymorphonuclears with concomitant drop in lymphocytes. In the course of the treatment, the separation of the curve registering the polymorphonuclears from that registering the lymphocytes is clearly apparent, the individual attacks being clearly discernible, while the temperature curve remains throughout the treatment, with slight variations, at 37.5° C. Thus, the leucocyte curve in man, as in the case of monkeys, is a better indication of the continuance of the disease than the temperature curve. The only difference between the blood findings in monkeys and in man appears to concern the eosinophiles; that is, a considerable increase in this form of leucocytes in man throughout the infection and treatment, while in monkeys the eosinophiles

varied very slightly and insufficiently to serve as a signal of the infection.

That the blood picture, as just discussed, is characteristic of rat-bite fever in general is evident from the fact that it was found in monkeys as well as in man and that our findings in the Philippines agree with those made elsewhere. So, for instance, Kuipers and Ruys [7] made identical findings in a human case of rat-bite fever in Holland. They summarized their findings as follows: Leucocytosis with relative lymphopenia and an eosinophilia was found during the attacks. The number of eosinophiles rose markedly a few days before the attacks. Eosinophilia occurred during convalescence.

Ishizu Yoshitada injected the blood of rat-bite fever into guinea pigs and found a distinct leucocytosis with relative and absolute diminution in the number of lymphocytes and a more or less distinct increase in the pseudoeosinophiles and monocytes.

Our blood findings in experimental human rat-bite fever indicate that in an obscure case of human rat-bite fever hæmatologic examinations may aid in establishing the diagnosis. It may further serve as a directive of treatment.

EXPERIMENTS CONCERNING IMMUNITY

In the following experiments we have endeavored to obtain as much information regarding immunity in rat-bite fever as is possible to secure by animal experimentation. By varying certain factors and leaving others unchanged we have studied the effect of particular factors upon the course of the infection in experimental animals. It has been found in series of experiments that by observing certain precautions, as to the mode of inoculation and as to the quantity of inoculum, certain manifestations of rat-bite fever occur in experimental animals with a constant regularity. It was hoped that by variations of the factors some modification of the course of the infection might become apparent that would enable us to recognize them as signs of beginning or partial immunity. The initial lesions, the fever, the change in body weight, and the occurrence of the spirochætes in the blood stream were constant signs of successful infection in experimental animals. The experiments were

[7] Kuipers, F. C., and A. Charlotte Ruys, Een geval van ratterbeetz-siekte [A case of rat-bite fever], Nederl. Tijdschr. v. Geneesk. 72d year, 1st half, No. 10 (March 9, 1929) 1207–1220. (With 2 charts and 4 figures on 1 plate; 18 references.)

arranged so that the dependency on the experimentally controllable factors of the degree of the symptoms and of the time at which the symptoms set in after inoculation might become apparent.

THE RELATION BETWEEN THE AMOUNT OF INOCULUM AND THE COURSE OF THE INFECTION

This experiment was arranged, primarily, for the purpose of finding indications in the appearance of the symptoms of the experimental rat-bite infection that might allow us to draw conclusions as to the progress of multiplication of the parasites in the host's body following inoculation. The experiment was arranged in the following way: Three guinea pigs of equal body weight were inoculated at the same time with decreasing amounts of the same inoculum. Blood of an infected guinea pig in which the spirochætes were present was used for that purpose. The three inoculated guinea pigs were examined daily with the view to establish the onset, extent, and duration of the following symptoms: The local lesion, the fever, and the presence of spirochætes in the circulating blood. It was found that in the first guinea pig, which received the largest amount of spirochætes, the local lesion developed early. It exhibited considerable inflammatory reaction besides induration. The second guinea pig, which received subcutaneously a smaller amount than the first one, developed local lesion without noticeable inflammation and somewhat later than the first one. In the third guinea pig, inoculated with the smallest amount of spirochætes, no perceptible local lesion developed.

The fever curve in the first two guinea pigs under discussion shows a moderate but typical rise. In the third guinea pig the elevation of the curve is smaller than in either of its mates. The onset and the duration of the fever in each of the three guinea pigs were the same, though they varied in degree. All three animals included in these experiments revealed the presence of spirochætes in the blood. The time necessary for the appearance of the spirochætes in sufficient numbers to be detected by the dark-field microscope in the circulating blood stood in inverse proportion to the quantity of the inoculum. That is to say, they were found first in the blood of the guinea pig that received the largest amount of spirochætes; later, they were found in the second animal that received a lesser dose than the first one; and in the third guinea pig, which received the small-

est amount of inoculum, the parasites appeared in the blood later than in the blood of either of its two mates.

One of the manifestations of rat-bite fever in experimental animals is loss of body weight. In this particular experiment, the three guinea pigs involved were of equal weight; that is, 350 grams each. In the course of the first month of infection, the two guinea pigs that manifested distinct initial local lesion and a distinct fever suffered a loss of body weight (80 grams). The third guinea pig, which received 0.001 cubic centimeter of the inoculum manifested no initial lesion and a slight elevation of temperature, gained 20 grams in the course of the first month of infection. The drop in body weight in the first two guinea pigs was particularly conspicuous after the fever subsided. During the same time the third guinea pig, which received the smallest amount of inoculum, registered increase in body weight. This change in body weight could not be attributed to any other factor for the animals were kept under the same conditions and no other change occurred, such as incidental infection, pregnancy, etc.

It is, therefore, evident that in normal susceptible animals the course of the disease and its manifestations, as well as the ultimate outcome, depend on the amount of parasites originally inoculated. The severity of the symptoms of experimental rat-bite fever, such as the initial lesion, the degree of fever, and the incubation of the septicæmic stage of the disease, stands in inverse proportion to the quantity of the parasites inoculated, equal virulence granted.

COMPARATIVE STUDY CONCERNING THE OCCURRENCE OF SPIROCHÆTA MORSUS MURIS AS TO TIME AND NUMBER OF PARASITES IN THE PRIMARY LESION AND IN BLOOD OF EXPERIMENTAL ANIMALS (GUINEA PIGS) INOCULATED WITH RAT-BITE FEVER.

This experiment was arranged in such a way that six guinea pigs were inoculated with a Manila strain of *Spirochæta morsus muris* by intradermal injection of a diluted blood of infected guinea pigs, which contained the parasites in sufficient numbers to be found with a dark-field microscope. The object was to follow the pathogenetic progress of the infection from the beginning to the end of the infection which invariably, with Manila strains, ended fatally.

PROCEDURE

After the inoculation the temperature of these animals was taken by rectum and inspection was made every day, spirochætes were looked for in the blood taken from the foot pad and from the local lesion. The material from the local lesion was taken as follows: The local lesion was held firmly between two fingers of the left hand and the center or the periphery of the local lesion was punctured, parallel to the surface of the skin with a sharp needle. After this, gentle pressure was applied with the fingers, fixing the local lesion until a serous fluid oozed out. This fluid was examined for the presence of spirochætes under dark-field illumination and by staining.

CONCLUSIONS

The results of this experiment show that the spirochætes are detectable in the local lesion on the first day of its development. In the blood they were demonstrable two to thirteen days (an average of seven days) later than in the local lesion, and in the majority of cases the spirochætes in the local lesion were more numerous at that early time than in the blood at any time during the infection. Furthermore, the demonstration of the spirochætes is easier in the primary lesion than in the blood, because of scarcity of the red cells in a slide made from the initial lesion.

The periphery of the local lesion showed more-numerous spirochætes than the center of the lesion.

This experiment demonstrates that the spirochætes (*Spirochæta morsus muris*) increase first at the point of inoculation and spread therefrom to the periphery. Later they invade the blood.

IMMUNITY IN EXPERIMENTAL RAT-BITE FEVER

Having become familiar with the clinical course and manifestations of rat-bite fever in various experimental animals, as produced by the Manila strains, we have arranged a series of experiments to study the effect that an infection by *Spirochæta morsus muris*, in experimental animals, may have on the clinical course and manifestations of subsequent inoculations. This was done in two ways: First, by superinfection; that is, by inoculation performed on animals already inoculated and in which the parasites were still demonstrable. The second procedure was

to study the effect of the preceding infection that has been terminated by specific treatment on the course of subsequent infection by the same strain of spirochætes as were used for the first inoculation.

SUPERINFECTION

Guinea pigs successfully inoculated with rat-bite fever were superinfected by intradermal inoculation at various intervals of time. The development of the local lesion at the point of superinfection was observed as to its incubation period, extent, clinical character, and the number of spirochætes it contained. The effect of the superinfection on the existing lesions that were produced by the first inoculation was studied and the effect of the superinfection on the fever curve, on the parasites in the blood stream, as well as on the mortality was noted. It has been observed throughout these experiments that superinfection with rat-bite fever produced at times a distinct effect on all the manifestations of the first infection, that have been just mentioned; that is, the superinfection produced a change in incubation of the local lesion, distinct rise of the temperature curve, a vigorous local lesion, at times an exacerbation of preexisting skin lesions, and more rapid death than in single inoculated animals. Although not all of these manifestations occurred always and in every experimental animal, yet the compiled findings of these experiments indicate that superinfection performed in the early acute stage of experimental rat-bite fever has a distinct and definite effect on the existing infection in the negative direction. The superinfection produces what may be termed a negative phase, and rat-bite fever being an infection with high mortality it ends inevitably in the early death of the animals concerned.

The results of experiments concerning superinfection with *Spirochæta morsus muris* showed that the course of the disease in superinfected animals was more rapid than that in single-inoculated animals of the same kind. While the average duration of the disease in single-inoculated animals was 56 days, the shortest being 11 and the longest 130 days, the course of the disease in superinfected animals lasted on the average 45 days, the shortest being 33 and the longest 56 days. Another effect of the superinfection was noticeable in the number of parasites encountered in the circulating blood and in the time of their appearance in the blood. While in singly inoculated animals, fol-

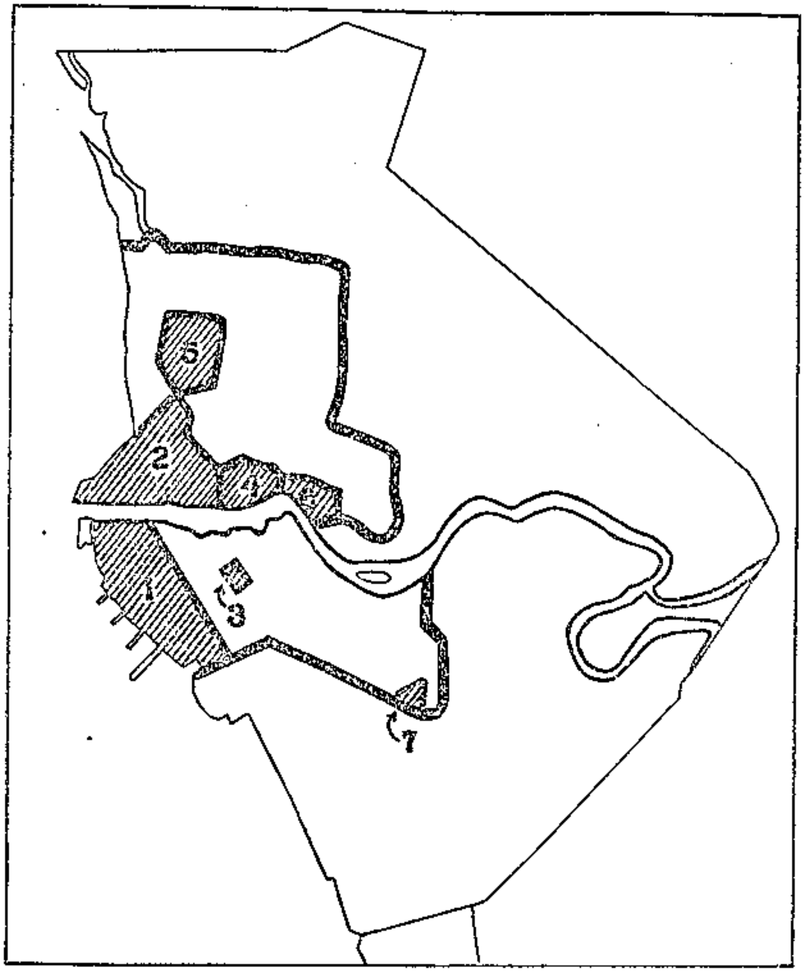


FIG. 1. Outline of the City of Manila, indicating danger zone and foci of greatest danger with regard to rat-bite fever and plague.

lowing the onset of fever, the parasites occur in the blood somewhat behind the beginning of the development of local lesion in the superinfected animals, the parasites were found in the blood at times as early as two weeks after superinfection. As to the number of parasites appearing in the blood, following the superinfection, in twelve of twenty-four animals enormous numbers of spirochætes were found in the circulating blood when superinfection was performed within seven weeks after the original inoculation.

REINFECTION

The rat-bite fever infection, in the experimental animals used, with the exception of mice, ended lethally. Following superinfection the death occurred much quicker than it did in single-inoculated animals of the same kind.

The possibility of investigating the conditions of immunity, as they may exist in rat-bite fever, by superinfection is therefore greatly limited by the early death of the animals and, beyond the negative phase, the subsequent stages of immunity could not be well ascertained by this procedure with the Manila strains. Therefore, it was decided to adopt another procedure for the study of the positive phase of the immunity in rat-bite fever; that is, of the partial or complete resistance to inoculation. The procedure of reinoculation that has brought satisfactory results on other occasions was adopted for the study of immunity in experimental rat-bite fever. By reinfection we understand inoculation performed repeatedly, each individual infection being terminated by specific treatment before the death of the animal, due to the infection, occurs. We have, therefore, inoculated successively a series of animals. As long as the animals did well in the course of the infection, the disease was allowed to run its course as long as possible without jeopardizing the life of the animals. When the general symptoms occurred—such as, loss of weight, loss of appetite, and general weakness—the animal was treated. It naturally happened, at times, that the infection was unintentionally allowed beyond the point at which the life of the animal could be saved. When the second and each subsequent reinfection was made, normal control animals were inoculated simultaneously with the same amount of the same inoculum to prove the viability of the material used as inoculum for the test of resistance.

By the process of reinfection it was found that certain clinical signs of experimental rat-bite fever failed to appear after the procedure of repeated inoculations and treatments has been continued for some time. The gradual disappearance of clinical symptoms in reinoculated animals followed a certain sequence. In this experiment it has been ascertained that the immune animals received a sufficient amount of the inoculum to cause normal control animals of the same species to develop the full clinical picture of the experimental rat-bite fever. The procedure of repeated inoculations has failed to develop some or all clinical manifestations of the disease. The typical clinical

symptoms of experimental rat-bite fever could be followed, step by step, in the normal control animals. It was noticed that in those animals that had been subjected to repeated reinoculations, the degree of the symptoms was considerably less than observed in normal control animals inoculated at the same time and with the same amount of the same inoculum. Thus, the incubation period, due to partially developed immunity, was changed; sometimes shortened, mostly prolonged. The initial lesion was far smaller and healed quicker than in normal animals. The fever was of less degree and the examination of blood revealed very few spirochætes in the circulating blood. In highly immune animals, the local lesion did not develop at all. The temperature curve of these animals showed no increase in intensity, running after repeated inoculations the same course and degree as before, and the spirochætes could not be demonstrated in the circulating blood by microscope.

This is the degree of immunity, as is known in syphilis and yaws, where inoculation of animals that have had the disease for some time produces no local or generalized clinical manifestations. These findings of absence of lesion, absence of fever, absence of the parasites in the blood, and absence of acute death in experimental rat-bite fever can be considered as the highest degree of immunity that the infection itself may produce.

These findings, however, as in treponematoses, do not indicate that the parasites in the infected body have been destroyed. When immune animals were sacrificed and the internal organs, such as the spleen and lymph glands, were inoculated into normal susceptible animals a typical rat-bite infection developed, proving that the tissues in question still harbored virulent *Spirochæta morsus muris*, even though in such small numbers that they could not be discovered by thorough microscopic examination.

In some of our animals the procedure of reinfection was continued for a considerable number of months, yet the findings in these animals were the same as in those that showed absence of clinical symptoms in the early stage of the experiment; that is, absence of parasites in the circulating blood as demonstrated by microscope. This indicates that a condition similar to that in syphilis and yaws exists in rat-bite fever. Once the body tissues of the experimental animals reached the stage of tissue nonreactivity, the immunity could not be forced higher by further reinfections performed in the stage of tissue nonreactivity.

CONCLUSIONS

The immunity in experimental rat-bite fever is analogous to that in treponematoses. It manifests itself by the absence of certain symptoms, as follows:

1. Change of the incubation period.
2. Change in degree or character of the local lesion that develops at the place of intradermal inoculation.
3. Absence of subsequent lesions surrounding the primary lesion.
4. Change in the degree of fever from a slight decrease to an absence of fever.
5. Total absence, even though temporary, of the parasites in the circulating blood.
6. Absence of acute death.

EXPERIMENTS CONCERNING INTRAUTERINE TRANSMISSION OF INFECTION AND IMMUNITY IN RAT-BITE FEVER

In its pathogenicity the disease known as rat-bite fever resembles treponematoses. The initial lesion, the subsequent skin lesions, the repeated relapses of lesions, and the positive serologic findings are manifestations that rat-bite fever has in common with syphilis and yaws. The question of intrauterine transmission of the infection is, therefore, of interest, in as much as the solution of this question, jointly with other experiments and observations, may lead to better understanding of the disease.

White mice were selected for these experiments for the reason that they exhibit a chronic infection and the mortality among them due to rat-bite fever is much lighter than among guinea pigs, rabbits, and monkeys. Monkeys, furthermore, rarely bear young in captivity.

Four litters of young white mice from three infected mothers were used. One of the mothers delivered young three days after the inoculation, the second one three weeks, and the third one five and ten weeks, respectively, after the inoculation. The two last-mentioned mothers presented in their blood demonstrable spirochætes at the time of delivery. Some of the young white mice were inoculated with rat-bite fever some time after birth, while the rest of them were not inoculated. The young were allowed to stay together, each litter with its mother. The blood of the young was examined every other day, before and after the inoculation for a period of thirty-one days; the blood of three of them, for a period of ninety-three days.

None of the young white mice, born of mothers infected with rat-bite fever, showed any evidence of either infection or immunity that might have been transmitted during intrauterine life. The relatively prolonged incubation period of the subsequent artificial inoculation among the young mice in question, as compared with that observed in normal controls, may tempt one to suspect that some degree of immunity may have been transmitted in utero, but the offspring of Ms–28 likewise showed prolonged incubation. It was born three days after the inoculation of its mother, hardly sufficient time for immunity to develop.

An additional experiment was performed with pregnant guinea pigs. Three guinea pigs in an advanced stage of pregnancy were inoculated with 0.03 cubic centimeter of guinea pig's blood containing numerous spirochætes. The inoculation was performed intradermally. The course of the infection was regular. However, all of the three pregnant guinea pigs miscarried. While in M–78 spirochætes were found in the blood of the mother two days before miscarriage, in M–79 spirochætes were not found until four days after miscarriage, and in M–80 they were found in unusually large numbers the day of miscarriage. In the first two guinea pigs, miscarriage preceded by two or three days the highest peak of the temperature curve, and in the third one the miscarriage was coincident with the finding of unusually large numbers of spirochætes in the blood. The fœtuses of M–79 were examined for spirochætes but none was found.

In this second experiment concerning intrauterine transmission of rat-bite fever, the evidence is again negative. It must be considered that in this experiment the infection was in its acute stage and set in already pregnant animals. The abortion was undoubtedly due to the high fever in these cases. In the experiment on mice, the infection was in its chronic, so to speak latent, stage when the pregnancy occurred. It terminated normally, fully developed living young mice having been born in due time. This difference in the arrangement of the two experiments may account for the difference in the course of the pregnancy.

In the available literature we found a report that bears on this question by Salimbeni, Kermorgant, and Garcia. These authors [8] claim that guinea pigs born of parents infected with

[8] C. R. Soc. Biol. No. 24 93 (1925) 337.

the spirochæte of rat-bite fever may become infected at birth. Our experiments with white mice supply no evidence of intrauterine transmission of either infection with rat-bite fever or immunity. Much might depend on the habit of the particular kind of animal, and the transmission of the disease appears to be more likely during the birth or shortly after than during the intrauterine life. (See transmission by contact.)

EXPERIMENTS CONCERNING TRANSMISSION OF RAT-BITE FEVER AMONG LABORATORY ANIMALS BY MEANS OF CONTACT AND BITE

DIRECT CONTACT

Two normal young guinea pigs were placed in the same cage with three other young guinea pigs. The latter-mentioned animals had received inoculation with rat-bite fever and in due time showed symptoms and manifestations of infection in the form of local lesions, fever, alopecia, loss of weight, and presence of spirochætes in the local lesion and blood. The two normal guinea pigs remained in direct contact with the three successfully infected ones for seventy-three days. Their temperature remained normal and spirochætes were not found in their blood. They showed neither skin lesion nor loss of weight during all this time. The five guinea pigs concerned in this experiment were young animals weighing 350 grams at the beginning of the experiment. Being young, they did not fight each other.

SUCCESSFUL TRANSMISSION OF RAT-BITE FEVER AMONG GUINEA PIGS BY BITE

A large male guinea pig, weighing 750 grams and infected with rat-bite fever, was placed in a cage with two normal male guinea pigs. In the fight that ensued, the large infected male guinea pig was observed repeatedly biting the normal guinea pigs. After due incubation, both of the bitten guinea pigs showed typical lesions, mostly on the back of the body at the places of bite. They both ultimately died, and spirochætes were found in the blood of one of them during life.

These two observations showed that transmission of rat-bite fever among animals (rodents) is not likely to take place by direct contact but that the disease is readily transmitted by bite. The animals concerned in this experiment harbored no bloodsucking insects.

THE DISTRIBUTION OF HUMAN CASES OF RAT-BITE FEVER IN MANILA (1931–1932) AS COMPARED WITH THE DISTRIBUTION OF HUMAN PLAGUE CASES IN THE SAME CITY IN 1912–1914.

INTRODUCTION

Having been the sole officer to examine personally, by laboratory methods, all of the suspected cases of bubonic plague among rats and humans during the last outbreak in Manila (1912–1914), the writer (Schöbl) projected more recently and carried out, with the aid of collaborators, investigations concerning rat-bite fever in the City of Manila, Philippine Islands. Tracing the human cases of rat-bite fever in Manila in 1931–1932, as to their distribution throughout the city districts, personal observations on bubonic plague of twenty years ago emerged from the writer's memory. A striking resemblance of the distribution picture of rat-bite fever in Manila with that of human plague, in the same city, became clearly apparent. The last outbreak of plague in Manila having been placed on record in all its details,[9] it was not difficult to draw a comparison of the two outbreaks, separated though they were by a span of twenty years, by the writer who remained continuously throughout that time in the same official capacity. The analysis and interpretation of the outbreaks with practical conclusions are presented in this communication.

In rat-bite fever we are dealing with an infectious disease of rats that shows a very low mortality and is transmitted from rat to rat and from rat to man directly. Clinical history of patients and experimental evidence support the claim that the disease is transmitted exclusively by a bite.[10] It is, therefore, a wound infection. The character of the wound and the clinical appearance of the primary lesion, which always develops at the site of the bite, are prima facie evidence of the occurrence; and the bite by a rat, being rather severe and painful, is an event which, in the daily life of any person, no matter how low his intelligence and acuteness of observation may be, cannot remain unnoticed by the patient himself or his relatives. The

[9] Jackson, T. W., Plague, etc., with bacteriological observations by Otto Schöbl. Press of J. B. Lippincott Company. Copyright, 1916; 192 pp., 10 illus.

[10] The possibility of rat-bite fever being transmitted by fleas is being investigated by Lieut. Surgeon S. Arima.

history given by the patient as to the place, time, and the donor of the infection is unerringly reliable. The clinical course and manifestations of the disease in man cannot be confused with any other known disease, and the demonstration of the causative agent by direct or indirect laboratory methods offers no great difficulty.

The epidemic as well as endemic of this disease is maintained continuously by rats. In man the disease, when properly treated, has no mortality. Human cases of rat-bite fever are sporadic, and the incidence is incomparably lower than that in plague.

Consequently, no radical and extensive control measures are necessary and the course of the epidemic as well as of the endemic among the rats, as indicated by the occurrence of human cases, may be allowed to run undisturbed by measures that are necessary for the control of an outbreak of bubonic plague. In other words, the condition prevalent in rat-bite fever is favorable for the study of outbreaks, epidemics, and endemics, of rat-borne human diseases in a particular community.

In bubonic plague, on the other hand, we are dealing with an infectious disease of rats (and other rodents) that shows a high mortality and is transmitted from rodent to rodent and from rodent to man indirectly by means of fleas, which may remain infectious for a considerable period of time after all infected rats in a given focus have been killed, either by rat-control measures or by death due to the disease itself. In addition to the variable factors in the spreading of rat-bite infection among rats, the variable factor of fleas enters into the spread and maintenance of plague infestation. In patients the place and the time when they acquired the disease cannot be ascertained from the history of the patient or from clinical findings. Thus, a search for plague-infected rats becomes necessary in places visited or occupied by the patient in the immediate past. This laborious and costly procedure of establishing the focus of plague infection in a community is rendered more difficult by the fact that due to the indirect transmission the plague epidemic among rats precedes that among humans; by the time the first case of human plague is found rats dead of plague may have been removed by street cleaners, by occupants of the premises, and by scavengers; therefore, no rats are found or, if found, they are beyond recognition as plague infected.

From this general discussion it should be clear that the study of the epidemiology of rat-bite fever in a port like Manila, which is constantly exposed to the introduction of bubonic plague from surrounding ports, the knowledge of rat-bite fever distribution should be of value as a guide for rat-control measures, provided that a close correlation exists in the epidemiology of these two rat-borne diseases. The importance of such study will be quite apparent with regard to Manila when it is considered that in the districts of the city that will be discussed later, and which from the standpoint of plague introduction represent the vulnerable spots of the city, no permanent improvement of the situation has been made in the last twenty years and no indication is seen that such improvement will be accomplished in the future. As in the past, the plague-control agencies will content themselves with emergency measures; that is, trapping and poisoning of rats and destruction of fleas in plague-infected districts when bubonic plague visits Manila, sooner or later, in the future. In the meantime, in the off season, rats are trapped as a preventive measure with the view of locating plague among rats; this has gone on at the rate of one hundred to two hundred rats a day for the last twenty years, to the intimate knowledge of the writer.

The distribution of the two rat-borne diseases in question may be presented by discussing the occurrence of human cases by districts. The introduction of the infection among rats may be well visualized if one acquaints the reader with the topography of the City of Manila where the shore life and the movements of the ship population and of the cargo take place. The common ship rat (*Mus norvegicus*) follows man. It is a city dweller and follows the transient human population. Spurred by the same motives as his human shipmate, when ashore, the ship rat visits and inhabits places where food is easily obtainable; the rat may have landed by going overboard or may have been landed with freight.

The wandering rats follow man on shipboard throughout all ports of the world. Ashore, in a port like Manila, they follow the routes of the ship's crew and the cargo. They are more likely to be left behind than their human shipmates and become permanent inhabitants of the port city where they deserted their ship.

The discussion regarding the distribution of the two diseases concerned necessitates a brief description of the City of Manila.

The City of Manila is located on Manila Bay and is divided into a northern and a southern section by Pasig River, which flows out of a lake located 25 kilometers south of Manila. The river within the City of Manila is spanned by three bridges designed for general traffic and one suspension bridge for pedestrians. The last of the four bridges, up the river, rests on a small island within the river, while the others are shore-to-shore bridges.

Throughout the city, but particularly in the section on the right river shore, are many canals, so-called "esteros," which communicate with each other and connect the bay with the river or the lower and the upper stream of the river. These canals serve as highways for transportation by means of which small row boats and lighters bring produce to the markets that are located on their banks. Some serve as highways for the distribution of ships' cargoes. This means of freight transportation is gradually giving way to motor-truck and other kinds of overland transportation. From the point of view of our discussion these canals represent a certain type of barrier and, like the river, determine, to some extent, the movements of the rat population; therefore, the spread of rat-borne diseases in Manila. Bridges, shallow places, and uncovered lighters make convenient crossings for rats.

Large ocean-going steamers come alongside the piers that are located in the southern section of the city; their lines are well protected by rat guards. Interisland steamers and craft of various sizes enter the river and tie up along either shore as far up the river as the bridges allow. Small barges and lighters go up the river beyond the first bridge and enter some of the canals. Consequently, from the epidemiologic standpoint the Manila water front includes, not only the bay shore but also the river front on both sides as far up stream as the first or perhaps the second bridge. The esteros represent extensions of the water front. Small craft tie up between larger vessels, touching each other or tieing to the sides of larger ships at times, so that rats can easily pass from ship to shore or from shore to ship.

The San Nicolas-Tondo district adjacent to the bay shore and to the northern river shore is easily the most-crowded section of the city with respect to human population. Quiapo and Santa

Cruz districts are about as thickly populated; however, the latter contain large empty squares and wide streets, which San Nicolas and Tondo districts lack. The largest number of storehouses ("go downs" or "bodegas,") are in San Nicolas and adjacent districts. The south shore of Pasig River, on the bay shore, is occupied by modern buildings, modern storehouses, and the Custom House, all located along the piers; while the storehouses in San Nicolas and Binondo districts are old buildings, mostly built in Spanish times. Separated from the piers area by wide playgrounds is the old Walled City, which represents from our point of discussion a city within a city. It has changed very little within the last two hundred years (see Plates 1 to 3). It is surrounded by playgrounds; that is, wide open spaces and parks where the old defensive moats used to be. The moats have been filled since the American occupation, planted with lawns, and gradually changed into playgrounds, parks, and the so-called "Botanical Gardens." Thus, this section of the city is bounded on three sides by playgrounds and parks—that is, wide open spaces—and on the northern side by the river. The old battlements, bastions, and fort walls are still preserved. No modern construction has taken place within the Walled City for many years. Immediately within the walls are large buildings occupied by Government offices, monasteries, colleges, and similar institutions—that is to say, buildings that are scarcely inhabited by a permanent population, and very few people remain in these buildings during the night. The heart of the Walled City is residential; the main blocks in the center contain restaurants and food-handlers' shops and represent the most-crowded section of the Walled City. They are the blocks surrounded by the four streets Anda, Cabildo, Potenciana, and Solana. There is no public market in this section of the town. One would hardly wish for a more-suitable spot than Intramuros in Manila to serve as a field for epidemiologic observations of this sort.

Foreign vessels arrive in Manila at the piers, which are located on the reclaimed land, the so-called "Port Area," on the bay shore in a southern direction from the mouth of the river. The buildings in this district are modern, as rat proof as possible, and offer little inducement for the immigrant rat to linger about. No case of human rat-bite fever was reported in 1931 from this area; which, though crowded with people during the daytime,

harbors little permanent population. Likewise, in 1912–1913 no human case of plague was found in this area. However, numerous dead rats were found and thrown into the bay by the guards of storehouses, and a cat kept in a storehouse as a rat-control measure was found sick and died of plague.

Adjacent to the Port Area and separated from it by a stretch of playgrounds, lies old Manila, Intramuros, the Walled City. As mentioned in the description of this district, the heart of the Walled City is the place where the ship's crew and the ship rat obtain food and refreshment. The four blocks of houses bounded by Cabildo, Potenciana, Solana, and Anda Streets, abound with small restaurants, refreshment places, bars, hotels, and ice-cream parlors. Real and Magallanes Streets intersect in these four blocks. Besides the food-handling establishments of various sizes, habitations both downstairs and upstairs are intermingled with crowded lodging places in these two-story houses.

Three human cases of rat-bite fever have been reported from these blocks. One contracted rat-bite fever in Anda Street, another in Solana Street, and the third in Cabildo Street.

The Walled City was visited by plague during the last two outbreaks in the City of Manila (1912–1914 and seven years previously). It was the only district of the city located south of the river where human plague has been contracted. The cases were few and easily traceable. During the 1912–1914 outbreaks, plague-infected rats were trapped in this locality; that is, in Cabildo and Anda Streets. The coincidence of rat-bite fever and plague, both in humans, is most remarkable in this district of the city due to its general unchangeable geographic condition.

Across the river and north of its mouth is San Nicolas district. The river front, from the lighthouse, which marks the mouth of the river, almost to the first bridge, is lined with all types of storehouses that harbor offices on the upper floors. Small restaurants, food-handlers' establishments, and bars line this river front within a few feet of the actual embankment.

From the river front this district spreads northerly into Tondo district and in the eastern direction into Binondo. San Nicolas district represents a triangle bounded by the river shore on one side; by a canal, Estero de Binondo, on the eastern side;

and by seashore and Azcarraga, a wide street, on the western side. The point of the triangle on Azcarraga reaches Tutuban Station, the main terminal of the Manila Railroad Company. On the eastern side of the Estero de Binondo lies Binondo district. It is bounded by the river shore, on the southern side by the Estero de la Reina, on the eastern by Azcarraga Street. The north side of Binondo is less inhabited than the southern. The greatest population is along Dasmariñas Street as far as the Binondo church and southerly as far as the Escolta, the main business street of Manila. To the north from these two districts of San Nicolas and Binondo lies Tondo district and the heart of it is Tutuban Station. These three districts might as well be considered as one from the viewpoint of epidemiology of rat-borne diseases. On two fronts they are bounded by water; namely, the bay and the river.

Four cases of human rat-bite fever were registered in these three districts, in places rather widely separated from each other.

During the last outbreak of plague 1912–1914 the greatest number of human-plague cases came from these districts. Also the largest number of plague rats was found there. Due to the crowded population and to the uninterrupted continuity of houses, it was at times difficult to group the cases of plague into definite foci. One point stands out, however, as significant. That is, the railroad storehouses at Tutuban Station, where fifteen cases of human plague among laborers were found within a few days. Here again the agreement between the distribution of rat-bite fever and plague is apparent. A case of rat-bite fever was contracted by a person living in Dagupan Street, which is the street facing the whole length of the railroad station on the western side.

Quiapo district, a comparatively small section, and the southern part of Santa Cruz, which is the district lying between Quiapo and Binondo, can be considered from an epidemiological standpoint as one. They are bounded westerly by the Estero de la Reina, southerly by the river front, easterly by the Estero de San Miguel, and towards the north the line is formed by the wide street Azcarraga, which runs in front of Bilibid Prison. This is the heart of commercial Manila. Two bridges for general traffic and one bridge for pedestrians connect the two shores of Pasig River within these epidemiologic districts. A large

of efficient ship-quarantine service, particularly in view of the fact that, as in Japan, in the Philippine Islands plague has been introduced in one or another port, from time to time; so that it is reasonable to conclude that bubonic plague knocks at the gates of the Philippines more frequently than is generally suspected, but it rarely gets by the plague-preventive measures imposed on ships by the quarantine. Introduced as an outbreak in a port of the Philippines from time to time, it has never become endemic, the reason for which may be speculated upon but has not been clearly demonstrated.

Bearing both rat-bite fever outbreaks and bubonic-plague outbreaks in mind, we can define in the City of Manila a danger area. This danger area starts north on the bay shore with the wide Estero de Vitas and follows this canal as far as Tondo Market. From there eastward, it follows Tayuman Street including the railroad terminal and San Lazaro Hospital as far as San Lazaro Race Course. From this point the border line runs southward as far as Bilibid Prison, following Andalucia Street as far as Azcarraga Street. It follows Ascarraga to the point where this street crosses the Estero de San Miguel. It follows this canal in a southerly direction to the point where the estero turns westward. That is the point where Acasia Street crosses rectangularly General Solano Street, which is the continuation of Echague Street, and where it touches the river shore. Crossing the river, on the opposite side, the line begins on the river shore at the foot of and following Cristobal Street to its crossing of Isaac Peral Street and from Canonigo Street, Paco, the line follows southerly along Paz Street to the point where this street reaches the Estero de Paco. From that point the line commences at the Estero de Paco, follows Tennessee Street, turns at the crossing of Kansas northerly to General Luna Street. It follows General Luna as far as Burgos Street. It turns along this street westerly to Katigbak Drive and to the bay shore.

One glimpse at the map will show that the danger zone on the right, the northern shore, of the river is far larger in extent and includes the most densely populated districts of the City of Manila; consequently, it is the most-difficult part of Manila with regard to plague-suppression control. The danger area on the southern shore of Pasig River is smaller in extent. It consists of three sections, separated from each other, unlike the zone on the northern shore. We can see that the districts of Ermita, Ma-

late, Santa Ana, Pandacan, Santa Mesa, and the northeastern sections of Sampaloc and Tondo are outside the relative danger zone. Within this entire danger area, as outlined, there are particular danger foci where both rat-bite fever and plague have been found in humans or rats. They are, first, the water front bounded by Pasig River, by the bay shore, separated from Intramuros and other districts by wide open playgrounds. Second in importance is the entire San Nicolas district. Third is the portion of Intramuros bounded by Anda, Solana, Potenciana, and Cabildo Streets. It would be well to consider these districts as the first danger zone. This area is cuneiform due to the extension of the water front within the city along the river shores. Adjacent to the San Nicolas district, and as a second danger zone, is the Manila Railroad focus bounded by Azcarraga, Antonio Rivera, Juan Luna, and Fajardo Streets. The part of Binondo district that is bounded by the river, the Estero de Binondo, the Estero de la Reina as far north as Ongpin Street, and the Quiapo district, adjacent to the Estero de la Reina, bounded by the river front, the Estero de San Miguel following its northern branch as far as Carriedo Street including Plaza Miranda, are districts that may well be considered the second danger zone. The northern part of Tondo, as far as Tayuman Street, on the northern shore, and Paco district, starting with Paco Market as a center, may be well considered the third danger zone.

The findings made in the study of the distribution of rat-bite fever in Manila do not indicate the succession of the invasion by this disease of Manila districts. The disease evidently has become endemic in Manila. Plague is introduced into Manila from outside ports. However, the distribution of rat-bite fever shows that besides the districts visited usually by sporadic outbreaks of plague in Manila others may be successively invaded. Paco district, for instance, has never been known to be invaded by plague, yet cases of rat-bite fever were found there. This observation seems to be a hint that should rat plague spread again in Manila, it would undoubtedly follow the same routes as rat-bite fever did and Paco district in the neighborhood of the market is more likely to be invaded next to the usual foci of plague. Plague may spread farther on the southern shore of Pasig River from Paco district rather than from Intramuros or from the Port Area.

RECOMMENDATION

The main object of securing samples of rats in a city that is either infested or threatened with bubonic plague is to locate the foci of plague infection among rats. Thus further suppression measures, such as destruction of fleas and protection of inhabitants, can be intensified and concentrated in places where the greatest danger lies. The particular spots designated in our discussion as foci of greatest danger represent the points in the City of Manila where the contact between the human and the rat population is most intimate. They are places where rat-borne diseases have occurred repeatedly. It seems to be a matter of logical deduction to expect that trapping and poisoning of rats at these points, throughout the city, must lead to early detection of rat-plague infestation. It would seem, therefore, both rational and advantageous as well as economical to concentrate trapping of rats in the places of greatest danger; that is to say, in Manila, the Port Area, the Solana-Cabildo-Potenciana-Anda blocks, and the San Nicolas district, particularly along Santo Cristo, San Fernando, and Del Pan Streets, the surroundings of Tutuban Station and Quiapo and Paco Markets. The reduction of the rat population in these particular places would have as a consequence immigration of rats from the surrounding vicinity of these particular foci where food for rats abounds. Thus, with less financial outlay the greatest efficiency in locating the plague rats can be achieved. This holds particularly true during the offseason. In case that plague rats were found in the designated places, the rat-suppression measures could be extended from these foci fanlike through the vicinity. This seems to be a more-rational and less-expensive procedure than the plan that was used in the last plague epidemic in 1912–1914. Circles were drawn, then, through the City of Manila and trapping began on the periphery of the largest circle. From this outer circle the rat-destruction measures followed the radius up to a point where plague was detected among rats and the trapping was then extended sidewards from the intersection of the radius and the nearest circle. It was a very extensive and costly measure and, no previous information being available to the authorities, was the only one to follow. It brought forth information which, strengthened by the study of the rat-bite fever in recent times, should serve to develop a plan that would yield the

desired information more rapidly at far less expense to the Government.

As a matter of fact, the original plan of trapping rats along the circles and radii had to be abandoned when human plague broke out in various points in the city. The rat-control measures had to be concentrated at the places where human cases of plague occurred. At that time the trapping, performed in the vicinity of the foci of human plague, yielded little information as to rat infestation, for the obvious reason that previous to the occurrence of human cases the greatest bulk of the rats have succumbed to the plague epidemic and plague-infected rats were rarely found in the houses and dwellings of plague patients. The human cases, being a consequence of rat plague with a high rate of mortality among rats, naturally occurred weeks after the rat epidemic. The infected fleas left the dead rats and not being able to encounter their natural prey, since all the rats had died or had been killed, pressed by hunger attacked humans. The second phase of the rat control in 1912–1914 was far behind the possibility of finding plague-infected rats. The plan suggested by our investigation would undoubtedly detect plague rats sooner due to the fact that the places in which to locate the plague rats became known and the entire force of antiplague control could be concentrated in smaller areas under this plan rather than scattered over a large area in the entire city as was done under the plan of 1912–1914.

SUMMARY

A comparison is presented between the distribution of human plague and rat plague in the City of Manila in 1912–1914 on the one hand and the distribution of human cases of rat-bite fever in Manila in 1931–1932 on the other hand. A complete agreement as to the districts affected by plague and those affected by human rat-bite fever is pointed out by discussion of personal observations made by the senior author during the outbreaks of the two rat-borne diseases that occurred twenty years apart. A tentative prediction of the progress of rat plague in Manila is outlined and a plan of attack against rat plague is proposed that is based on the reoccurrence of the two rat-borne diseases in the same localities in the city. The usefulness of the study of the distribution of rat-bite fever in a city free from plague, but constantly threatened by invasion from neighboring ports, is emphasized.

TABLE 1.—*Showing the results of experiments concerning the viability of Spirochæta morsus muris.*

Designation of guinea pig.	Body weight.	Temperature.	Time of exposure.	Date of inoculation.	Spirochætes found for the first time.
	g.	°C.	*Hours.*		
RB-27	270	26-27	([a])	VIII-20-31	IX- 2-31
RB-29	350	26-27	0.5	VIII-20-31	IX- 3-31
RB-49	370	26-27	1	VIII-20-31	IX-17-31
RB-30	300	26-27	2	VIII-20-31	VIII-31-31
RB-31	350	26-27	3	VIII-20-31	IX- 2-31
RB-32	300	26-27	4	VIII-20-31	IX- 3-31
RB-56	400	29-31	4	IX-4-31	IX-18-31
RB-57	650	29-31	6	IX-4-31	IX-18-31
RB-58	350	29-31	8	IX-4-31	IX-18-31
RB-59	550	<8	4	IX-4-31	IX-22-31
RB-60	500	<8	6	IX-4-31	IX-18-31
RB-61	250	<8	8	IX-4-31	IX-29-31
RB-62	700	37	4	IX-4-31	IX-22-31
RB-63	600	37	6	IX-4-31	IX-15-31
RB-64	750	37	8	IX-4-31	IX-15-31
RB-81	250	<8	8	X-6-31	X-24-31
RB-84	350	<8	24	X-7-31	None.
RB-87	300	<8	30	X-7-31	None.
RB-82	300	37	8	X-6-31	XI-24-31
RB-85	350	37	24	X 7-31	None.
RB-88	300	37	30	X-7-31	None.
RB-83	350	29-31	8	X-6-31	X-30-31
RB-86	250	29-31 24-29	24	X-7-31	None.
RB-89	320	29-31 24-29	30	X-7-31	None.

[a] Immediately.

TABLE 2.—*Results of search for Spirochæta morsus muris in the blood of inoculated Philippine monkeys.*

Designation of monkey.	Blood withdrawn, days after inoculation.	Recipient animal.	Spirochætes found.
	Days.		
Rb-6	8	Ms-19	No.
Rb-4 [a]	9	Ms-10	Yes.
Rb-20	9	M-100	
Rb-5 [a]	14	Ms-12	No.[b]
Rb-J-11	14	Ms-13	Yes.
Rb-1	17	Ms-7	Yes.
Rb-16 [a]	17	M-69	No.
Rb-18 [a]	23	M-72	No.
Rb-10	24	M-46	Yes.
Rb-15 [a]	29	Ms-45	No.
Rb-12	30	Ms-41	No.
Rb-Syp-25	59	Ms-16	Yes.
Rb-J-11	69 after first infection	M-15	Yes.
Do	13 after superinfection		
Rb-Syp-25	86 after first infection	M-13	No.
Do	11 after superinfection		
Do	143 after first infection	M-44	No.
Do	68 after superinfection		
Rb-Syp-26 [a]	219 after first infection	M-71	No.
Do	144 after first superinfection		
Do	67 after second superinfection		
Rb-3	88	M-14	No.
Rb-8 [a]	116	M-101	No.
Rb-7	127	M-104	

[a] Blood taken at autopsy. [b] Died the fourth day.

TABLE 3.—*Results of preventive chemotherapy in experimental rat-bite fever.*

[+, Infection developed; —, infection did not develop.]

Designation of guinea pig.	Drug.	Dose.	Result.	Controls.
M-133	Stibenyl	0.03 g	+	+
M-134	do	0.02 g	+	+
M-135	do	0.01 g	+	+
M-74	do	0.01 g	+	+
M-136	Antimosan	2 cc	+	+
M-137	do	1 cc	+	+
M-138	Quinine-iodo-bismuthate	0.025 g	+	+
M-139	do	0.0125 g	+	+
M-75	Stibosan	0.005 g	+	+
M-108	do	0.01 g	—	+
M-109	do	0.03 g	—	+
M-110	do	0.05 g	—	+

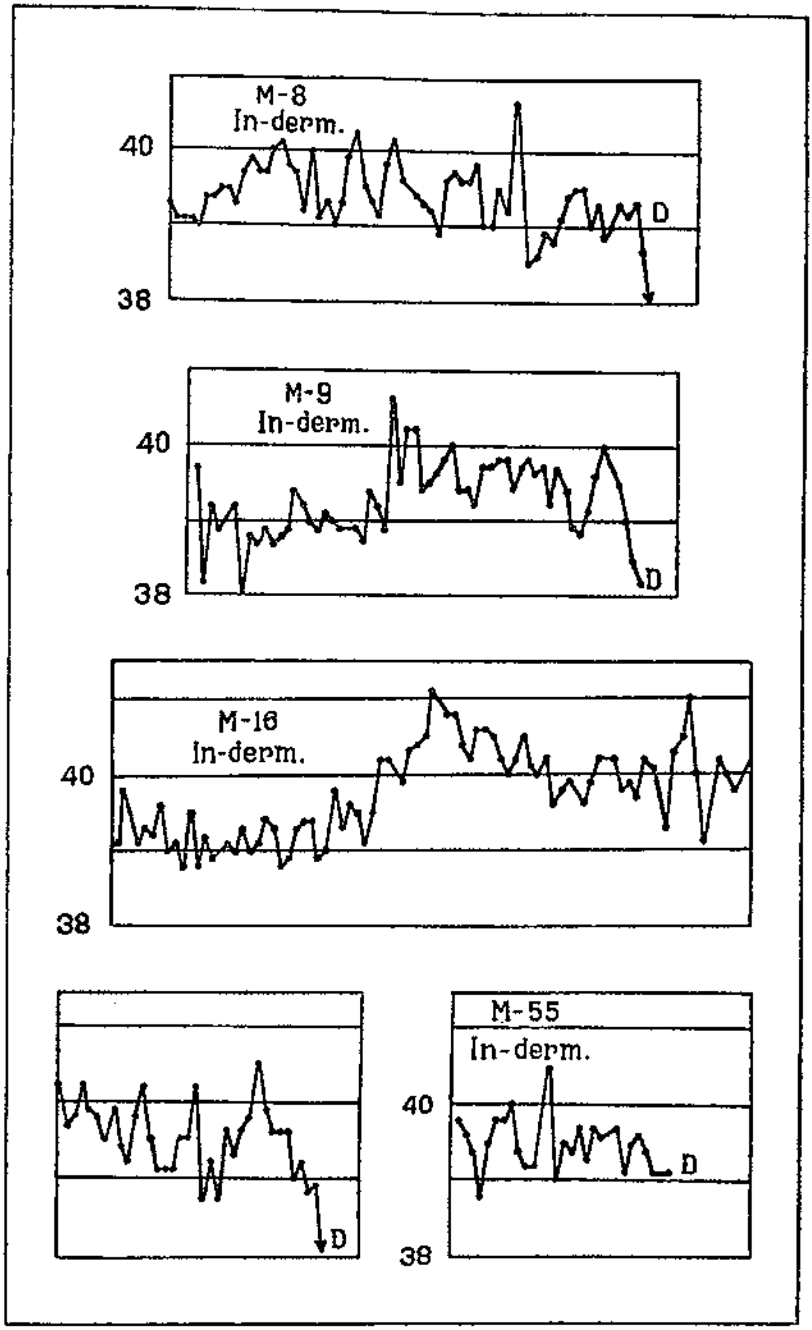

M-8
In-derm.
40
38
D
M-9
In-derm.
40
38
D
M-16
In-derm.
40
38
D
M-55
In-derm.
40
38
D

Fig. 2.

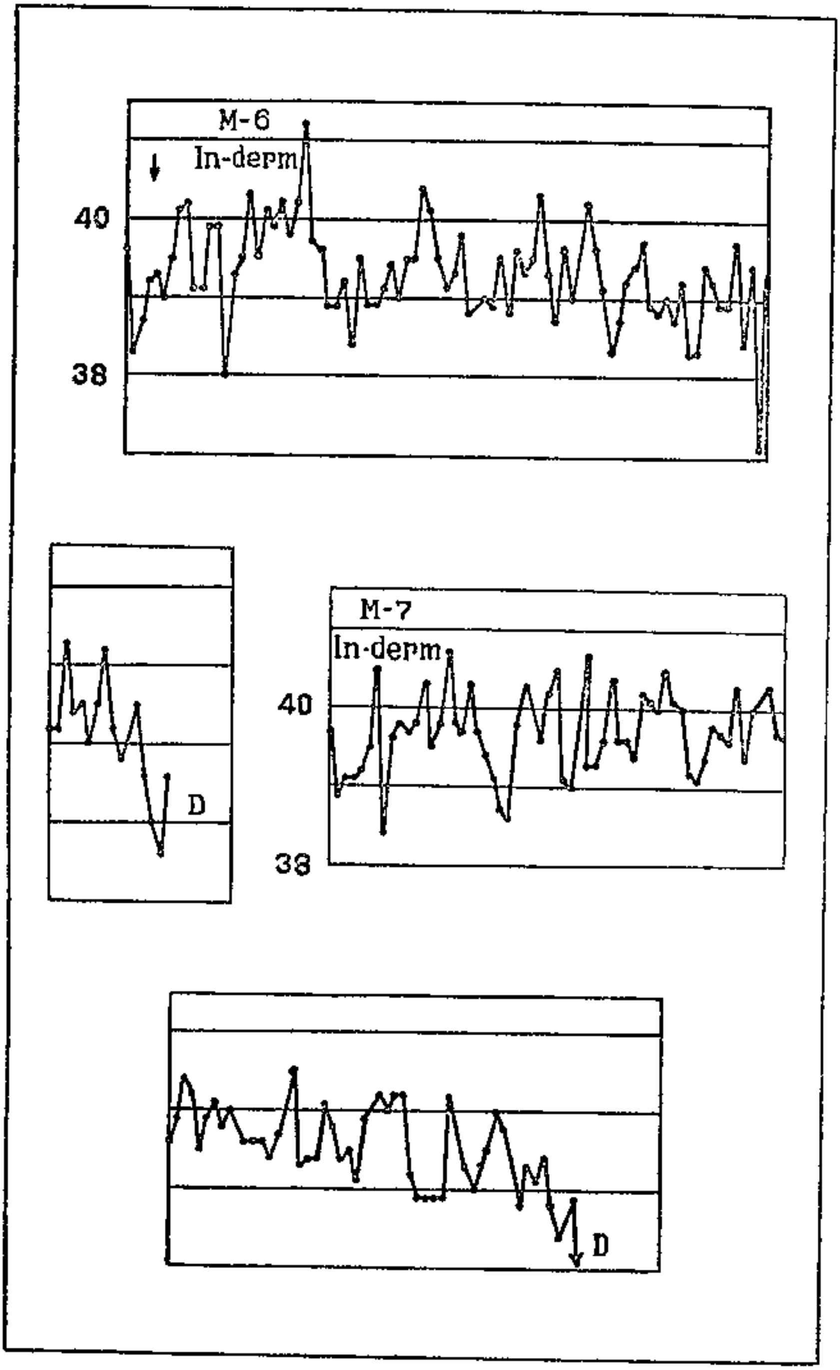
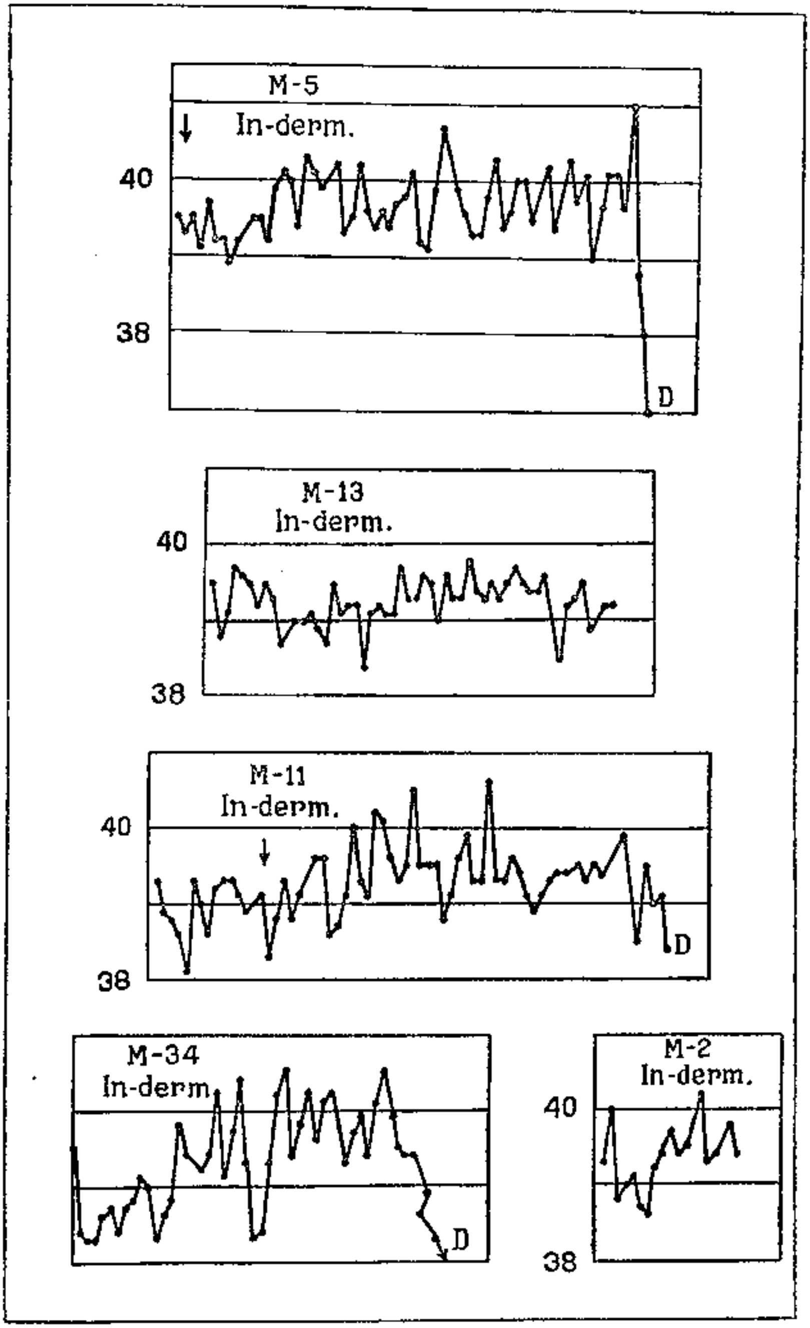


FIG. 3.



M-5
In-derm.
40
38
D
M-13
In-derm.
40
38
M-11
In-derm.
40
38
D
M-34
In-derm.
D
M-2
In-derm.
40
38

FIG. 4.

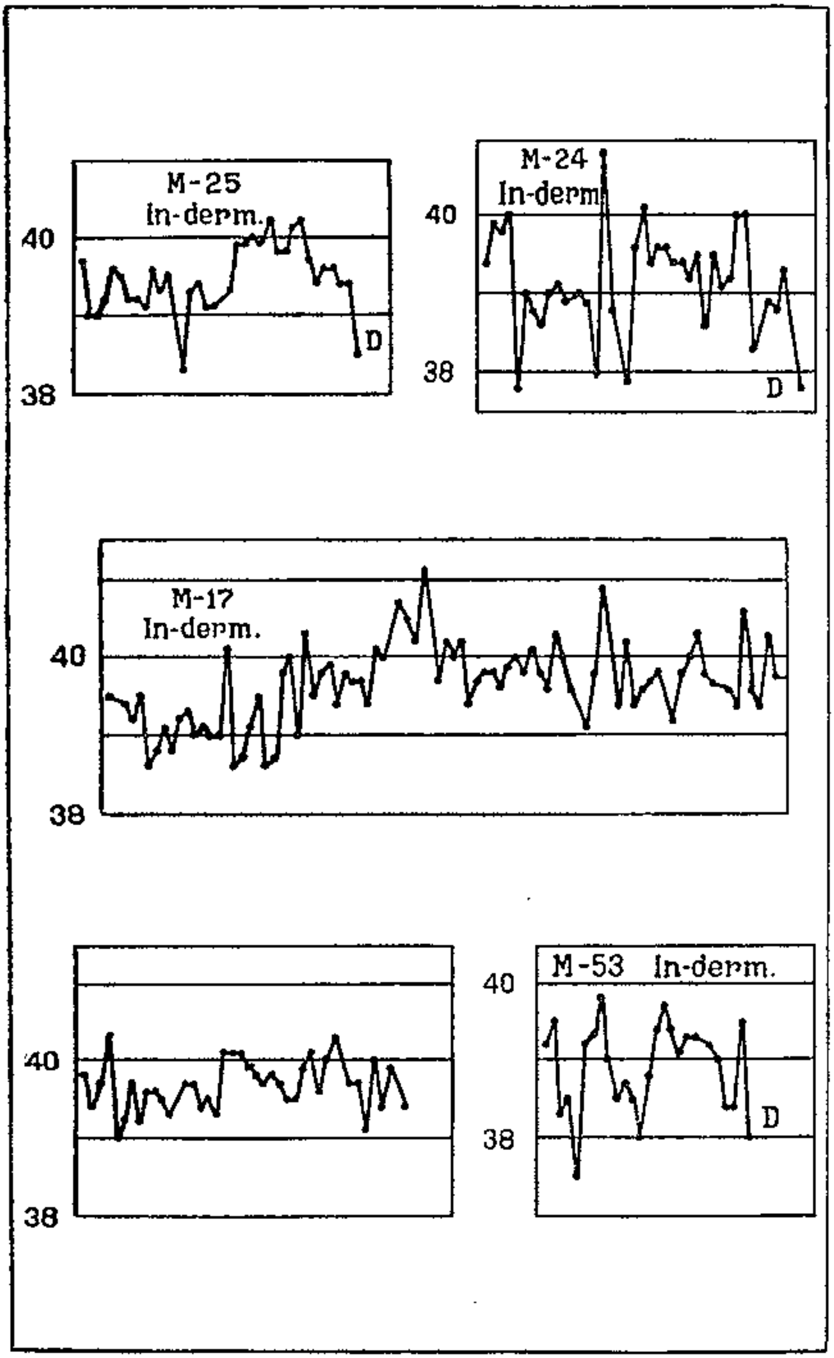

M-25
In-derm.
40
38
D
M-24
In-derm
40
38
D
M-17
In-derm.
40
38
40
38
M-53 In-derm.
40
38
D

FIG. 5.

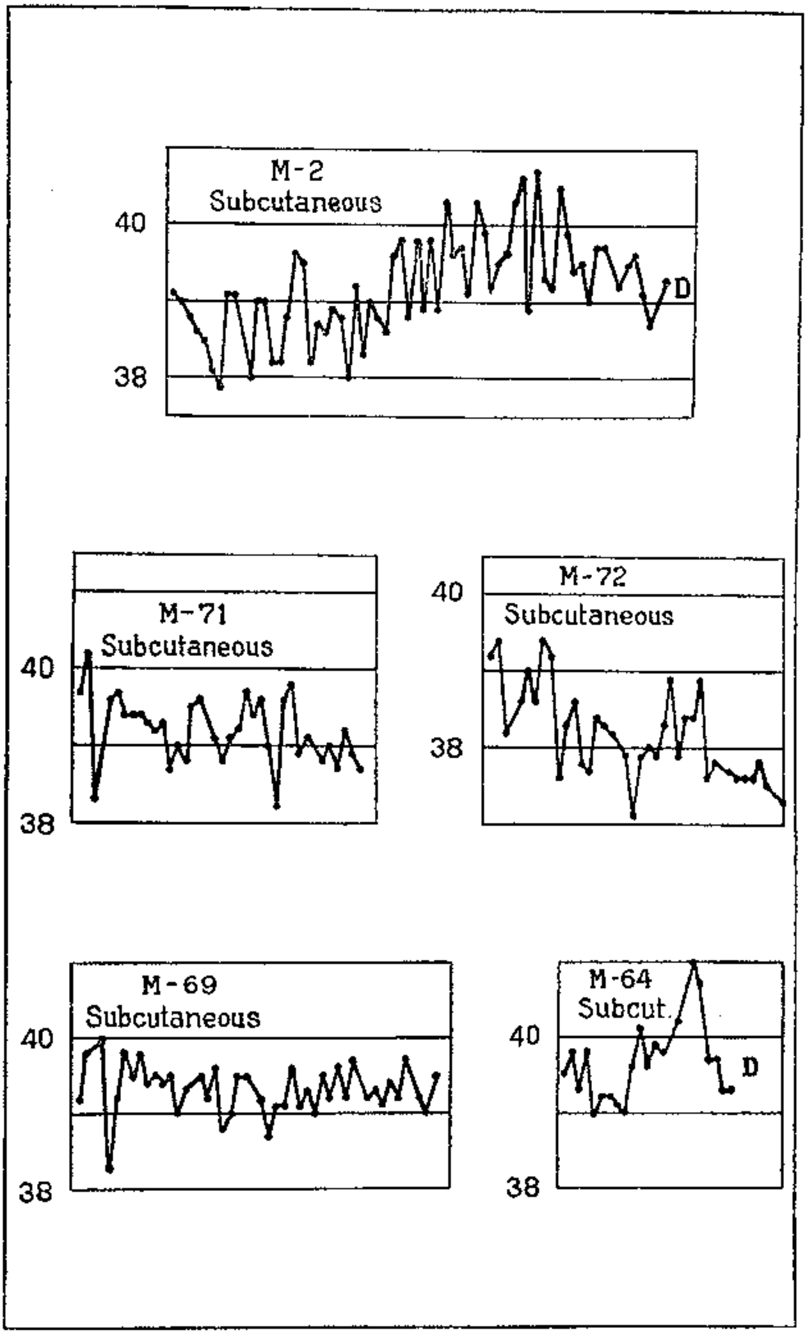

M-2
Subcutaneous
40
38
D
M-71
Subcutaneous
40
38
M-72
Subcutaneous
40
38
M-69
Subcutaneous
40
38
M-64
Subcut.
40
38
D

FIG. 6.

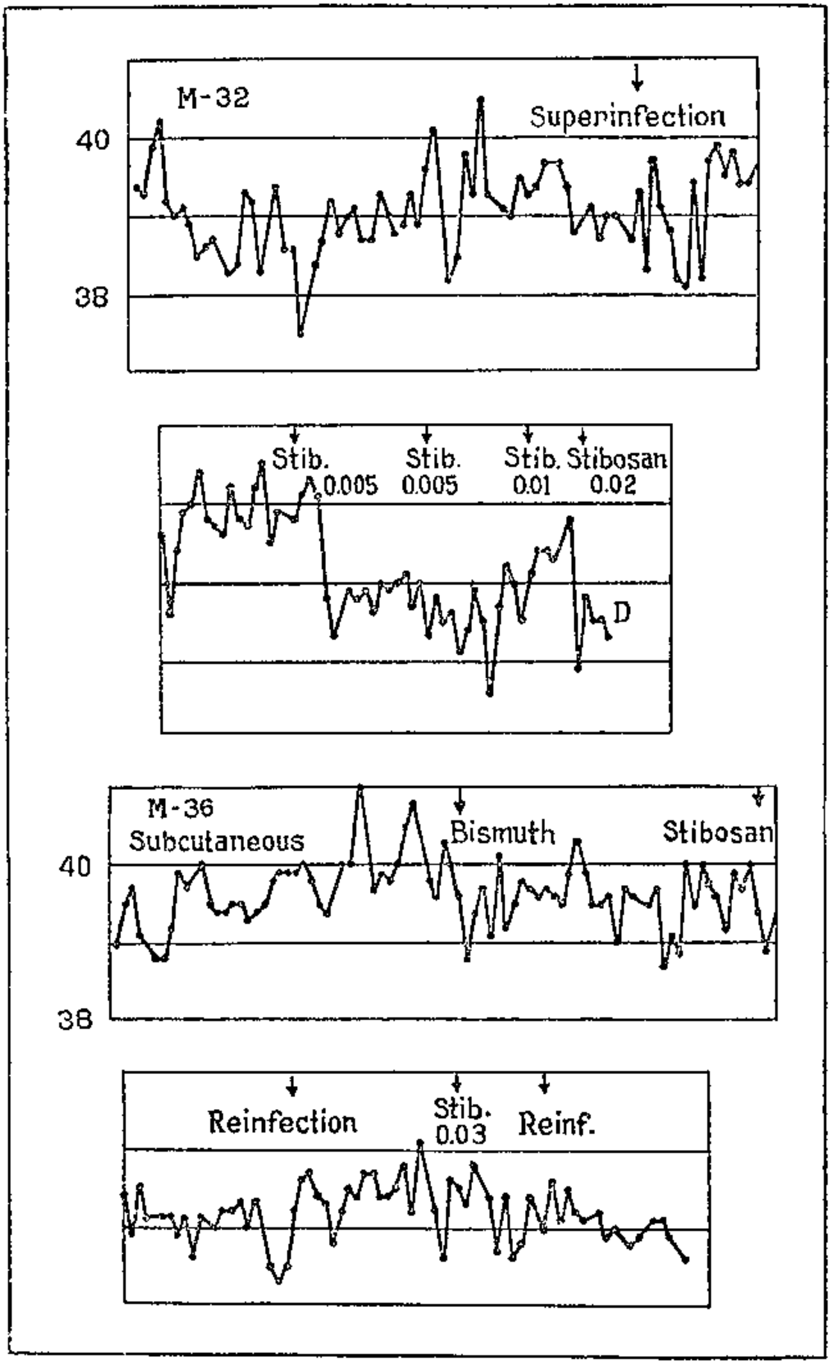

M-32
Superinfection
40
38
Stib.
0.005
Stib.
0.005
Stib.
0.01
Stibosan
0.02
D
M-36
Subcutaneous
Bismuth
Stibosan
40
38
Reinfection
Stib.
0.03
Reinf.

FIG. 7.

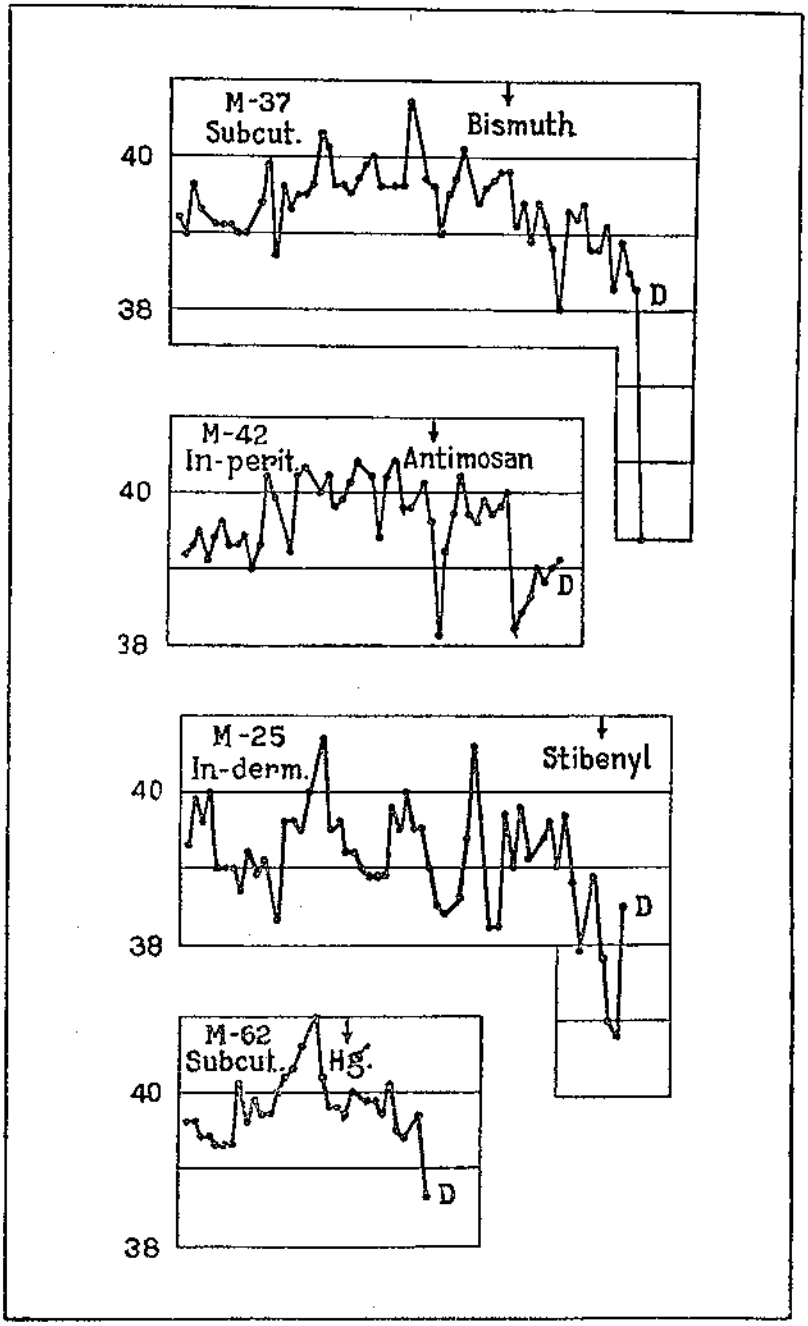

M-37
Subcut.
Bismuth
40
38
D
M-42
In-perit.
Antimosan
40
38
D
M-25
In-derm.
Stibenyl
40
38
D
M-62
Subcut.
Hg.
40
38
D

FIG. 8.

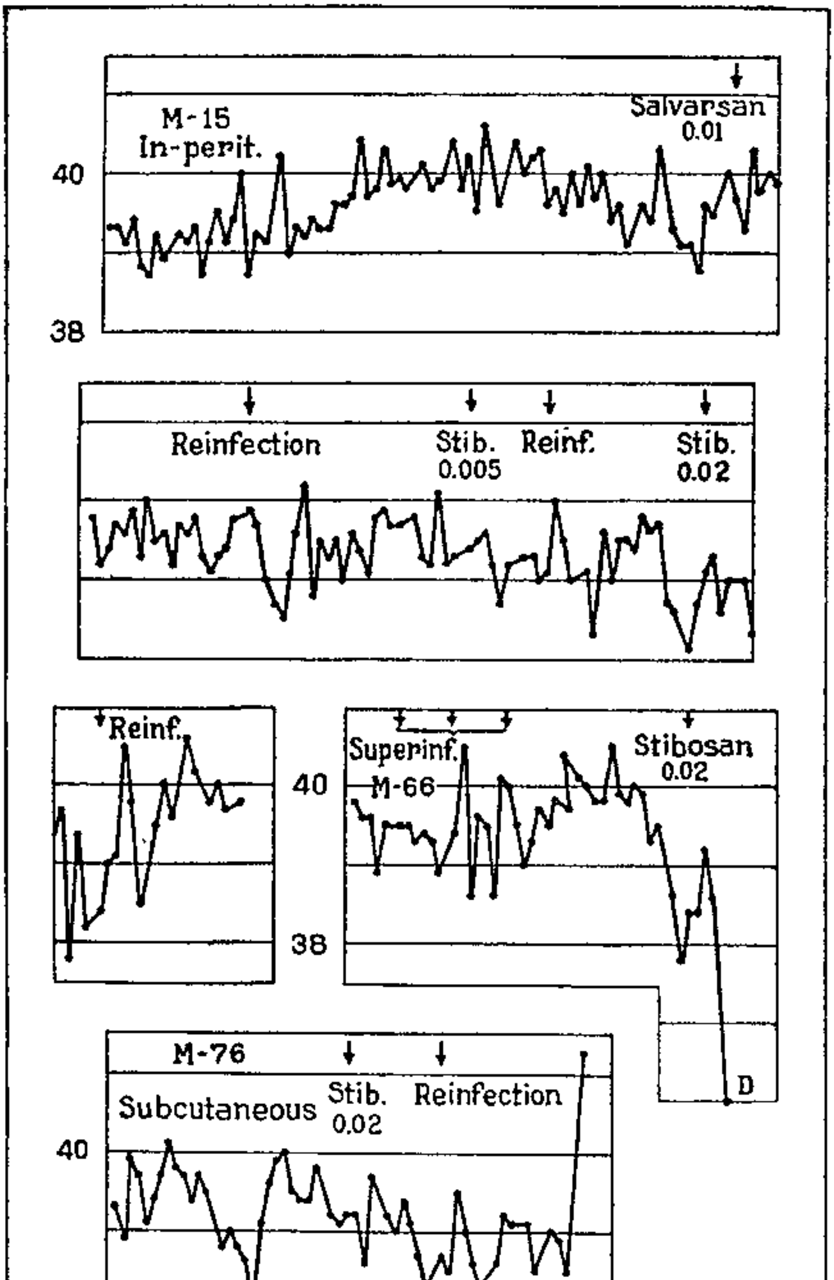

M-15
In-perit.
Salvarsan
0.01
40
38
Reinfection
Stib.
0.005
Reinf.
Stib.
0.02
Reinf.
Superinf.
M-66
Stibosan
0.02
40
38
D
M-76
Subcutaneous
Stib.
0.02
Reinfection
40
38

FIG. 9.

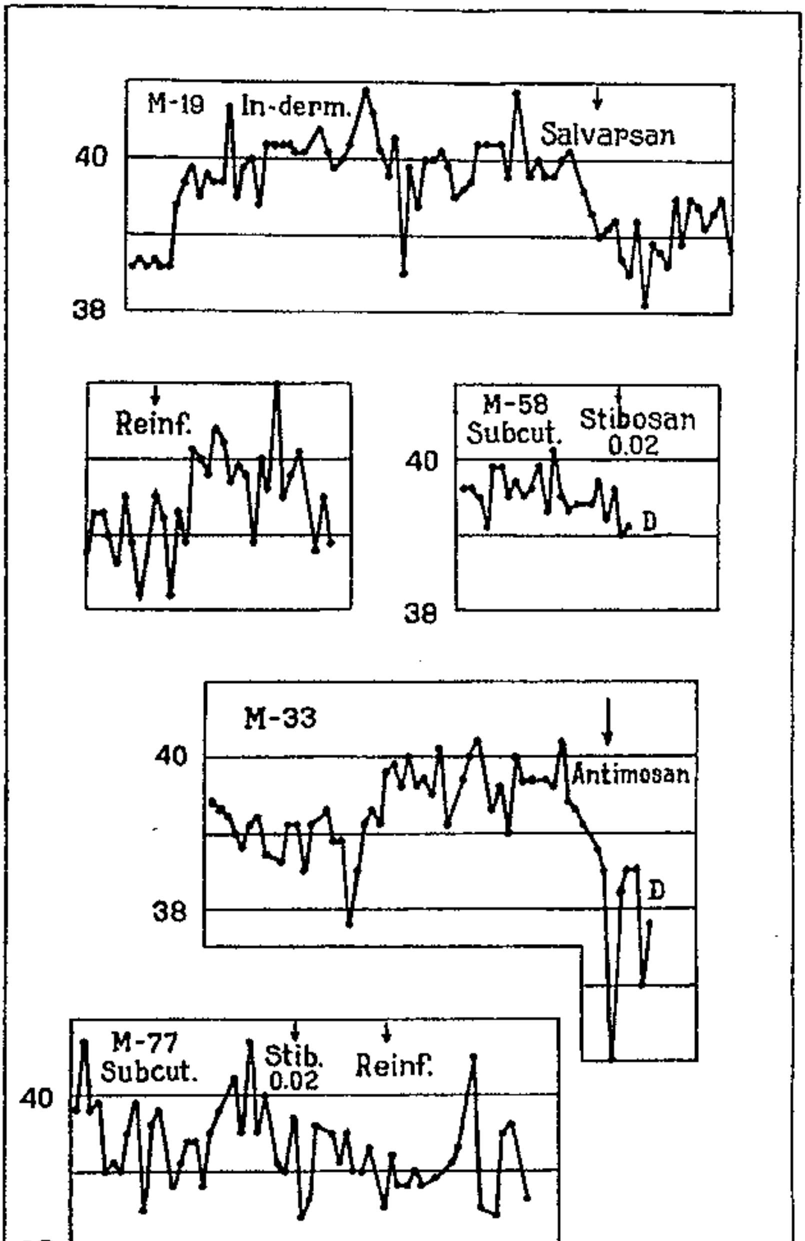

M-19
In-derm.
Salvarsan
40
38
Reinf.
M-58
Subcut.
Stibosan
0.02
40
D
38
M-33
40
Antimosan
38
D
M-77
Subcut.
Stib.
0.02
Reinf.
40
38

Fig. 10

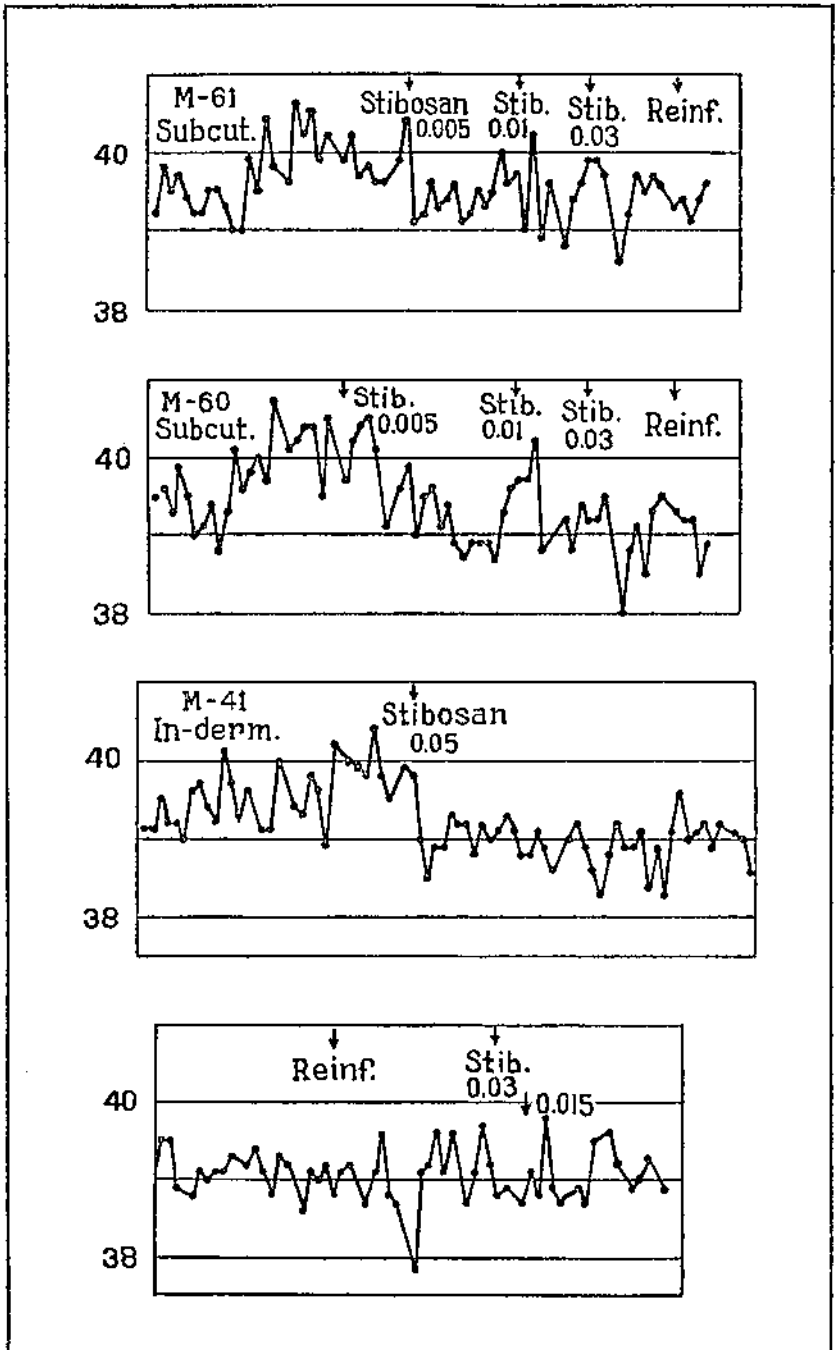

M-61
Subcut.
Stibosan
0.005
Stib.
0.01
Stib.
0.03
Reinf.
40
38
M-60
Subcut.
Stib.
0.005
Stib.
0.01
Stib.
0.03
Reinf.
40
38
M-41
In-derm.
Stibosan
0.05
40
38
Reinf.
Stib.
0.03
0.015
40
38

FIG. 11.

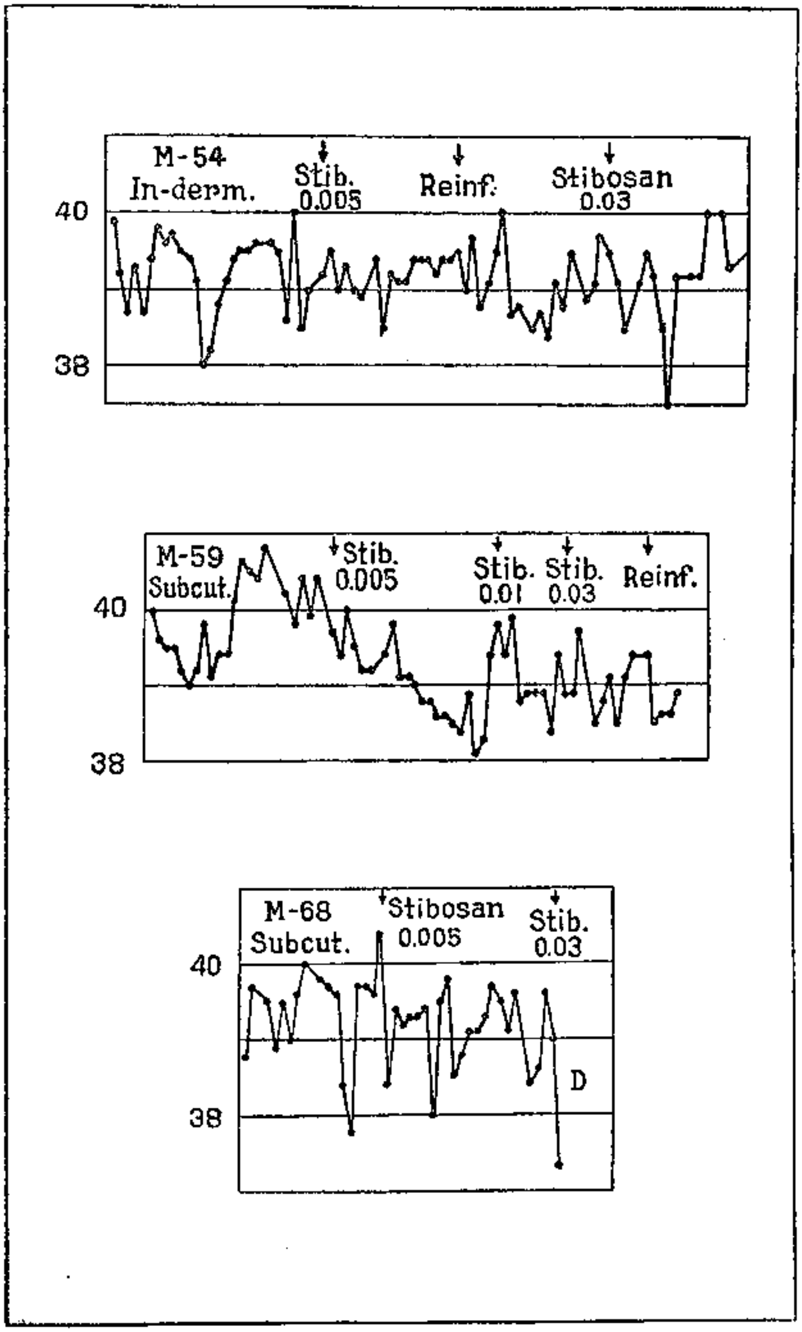

M-54
In-derm.
Stib.
0.005
Reinf.
Stibosan
0.03
40
38
M-59
Subcut.
Stib.
0.005
Stib.
0.01
Stib.
0.03
Reinf.
40
38
M-68
Subcut.
Stibosan
0.005
Stib.
0.03
40
38
D

FIG. 12.

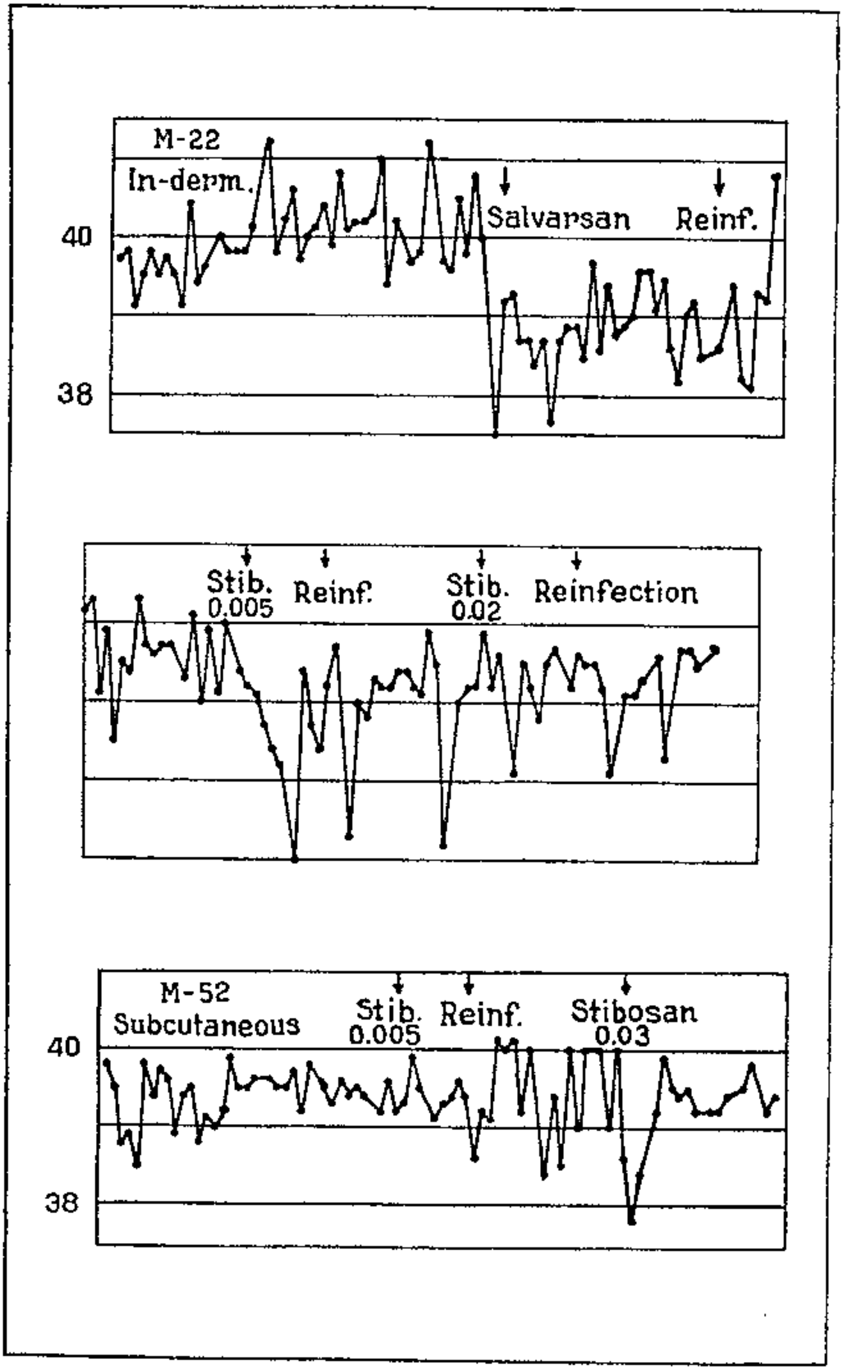

M-22
In-derm.
Salvarsan
Reinf.
40
38
Stib. 0.005
Reinf.
Stib. 0.02
Reinfection
M-52
Subcutaneous
Stib. 0.005
Reinf.
Stibosan 0.03
40
38

FIG. 13.

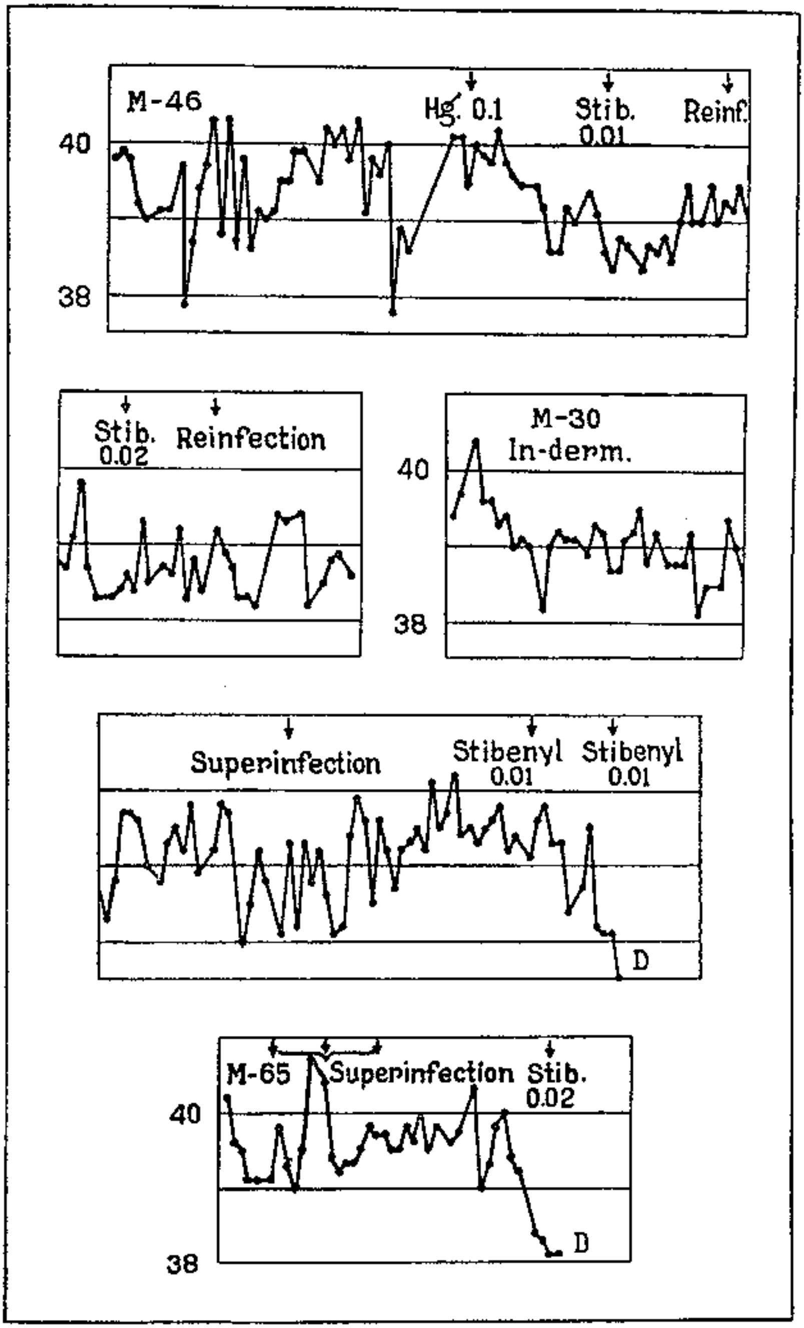

M-46
Hg. 0.1
Stib. 0.01
Reinf.
40
38
Stib. 0.02
Reinfection
M-30
In-derm.
40
38
Superinfection
Stibenyl 0.01
Stibenyl 0.01
D
M-65
Superinfection
Stib. 0.02
40
38
D

FIG. 14.

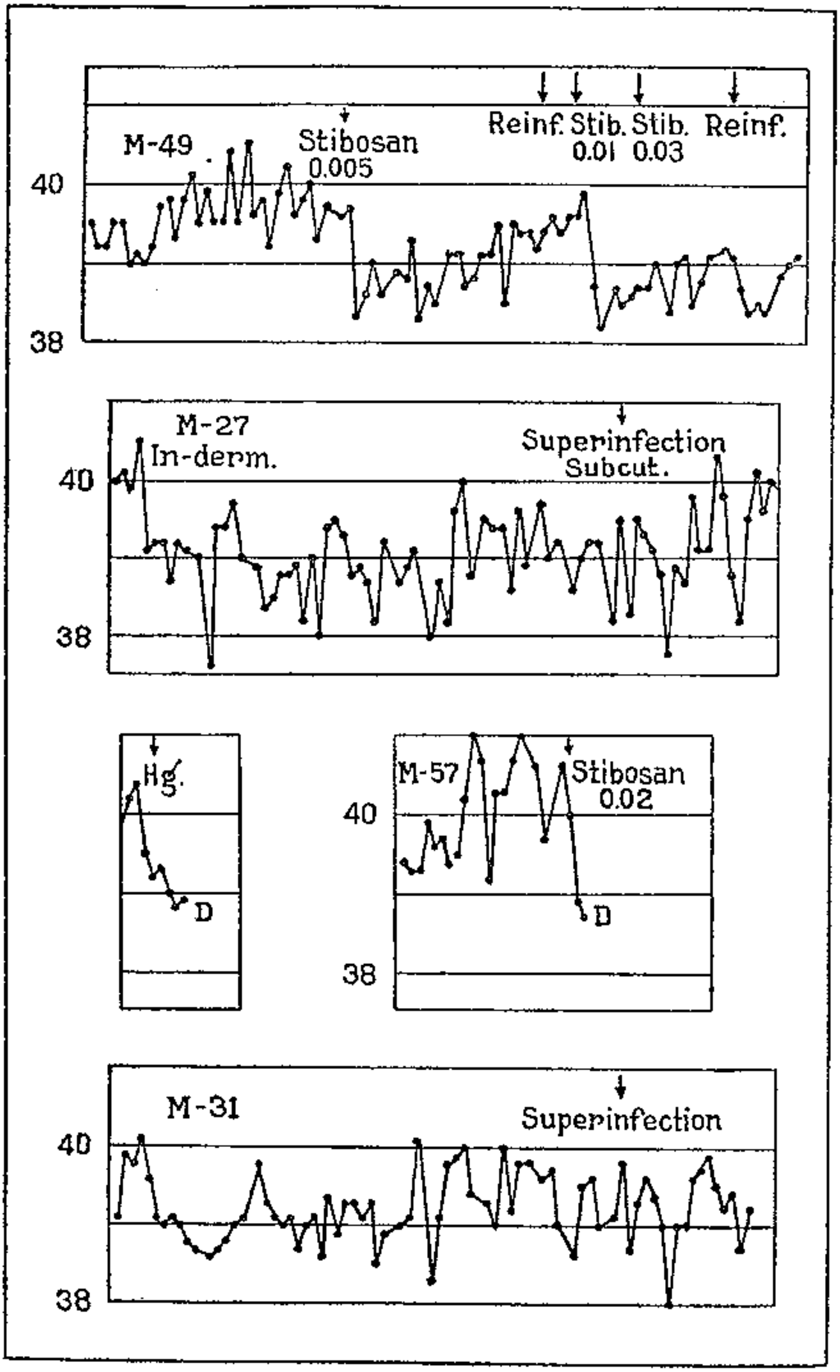

M-49
Stibosan 0.005
Reinf.
Stib. 0.01
Stib. 0.03
Reinf.
40
38
M-27
In-derm.
Superinfection Subcut.
40
38
Hg.
D
M-57
Stibosan 0.02
D
40
38
M-31
Superinfection
40
38

FIG. 15.

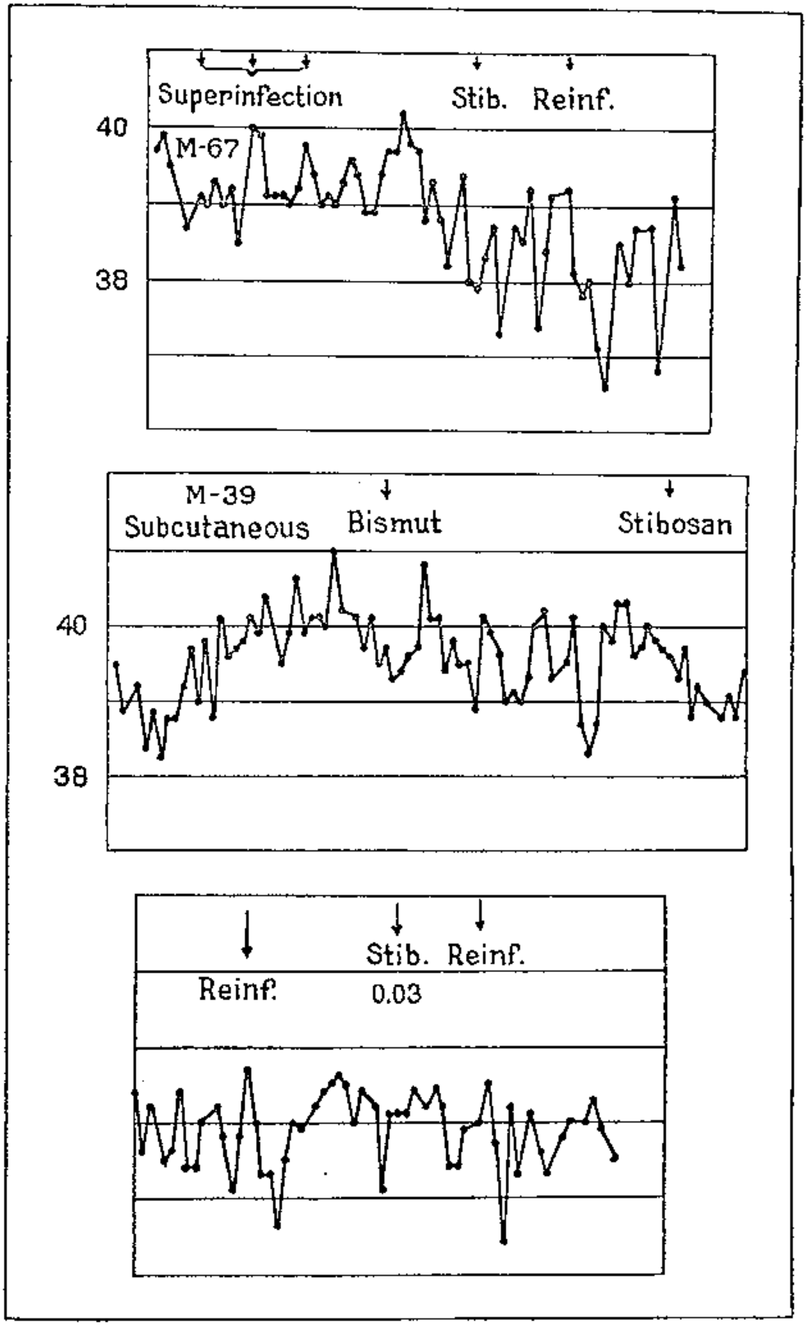

Superinfection
Stib.
Reinf.
40
M-67
38
M-39
Subcutaneous
Bismut
Stibosan
40
38
Stib.
Reinf.
Reinf.
0.03

FIG. 16.

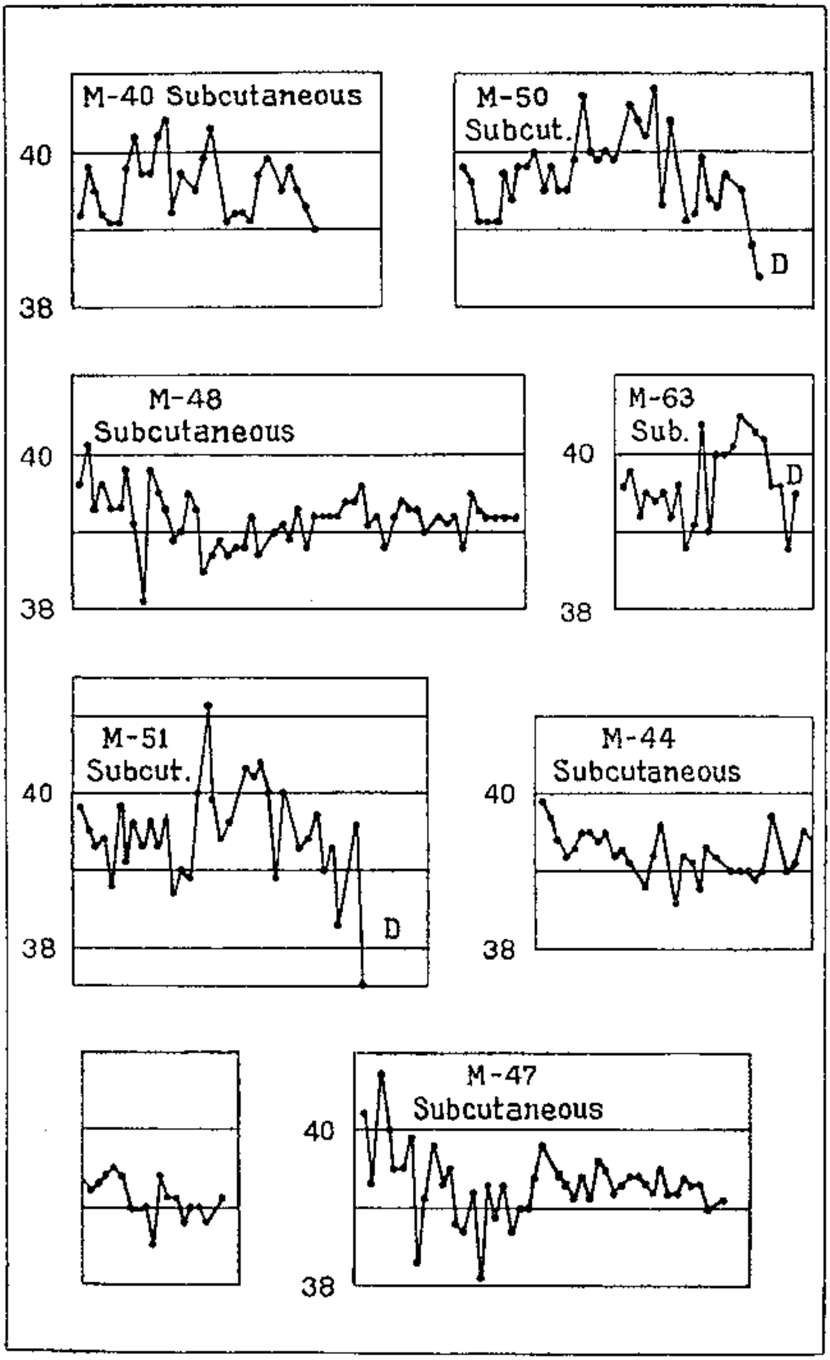

M-40 Subcutaneous
40
38
M-50
Subcut.
D
M-48
Subcutaneous
40
38
M-63
Sub.
40
D
38
M-51
Subcut.
40
D
38
M-44
Subcutaneous
40
38
M-47
Subcutaneous
40
38

FIG. 17.

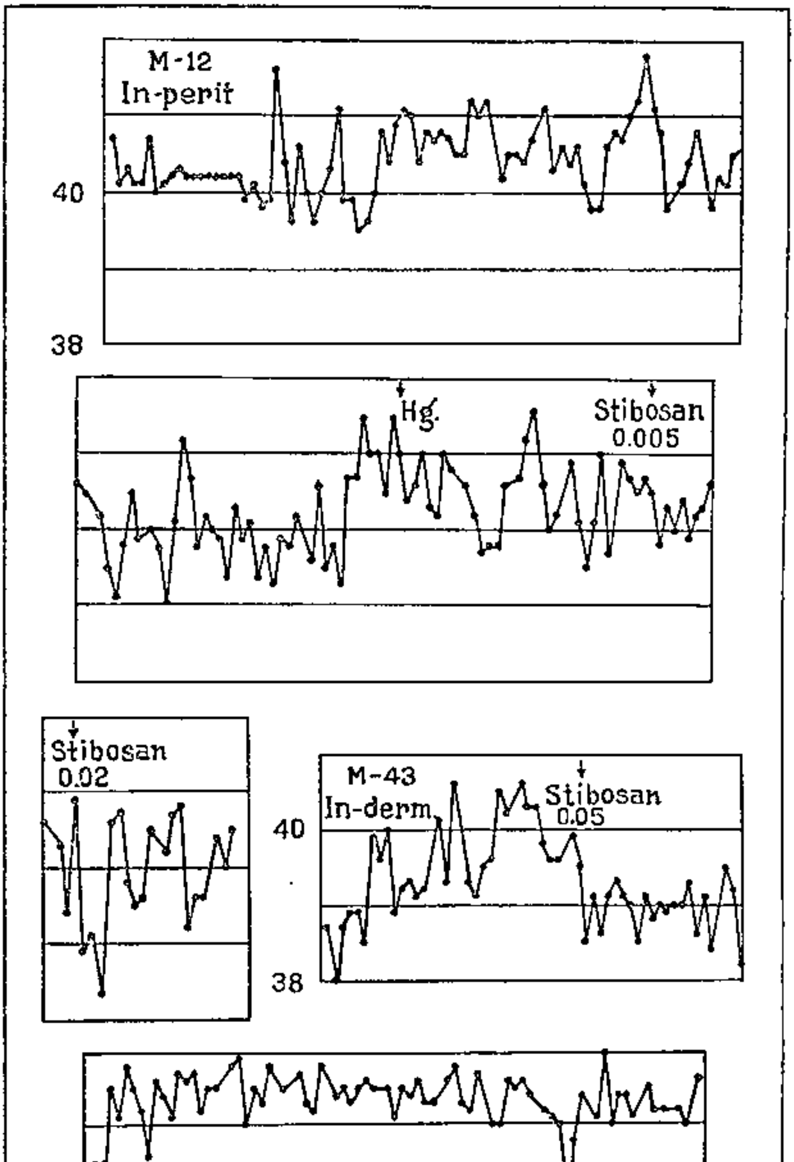

M-12
In-perit
40
38
Hg.
Stibosan
0.005
Stibosan
0.02
M-43
In-derm.
Stibosan
0.05
40
38

FIG. 18.

ILLUSTRATIONS

PLATE 1.

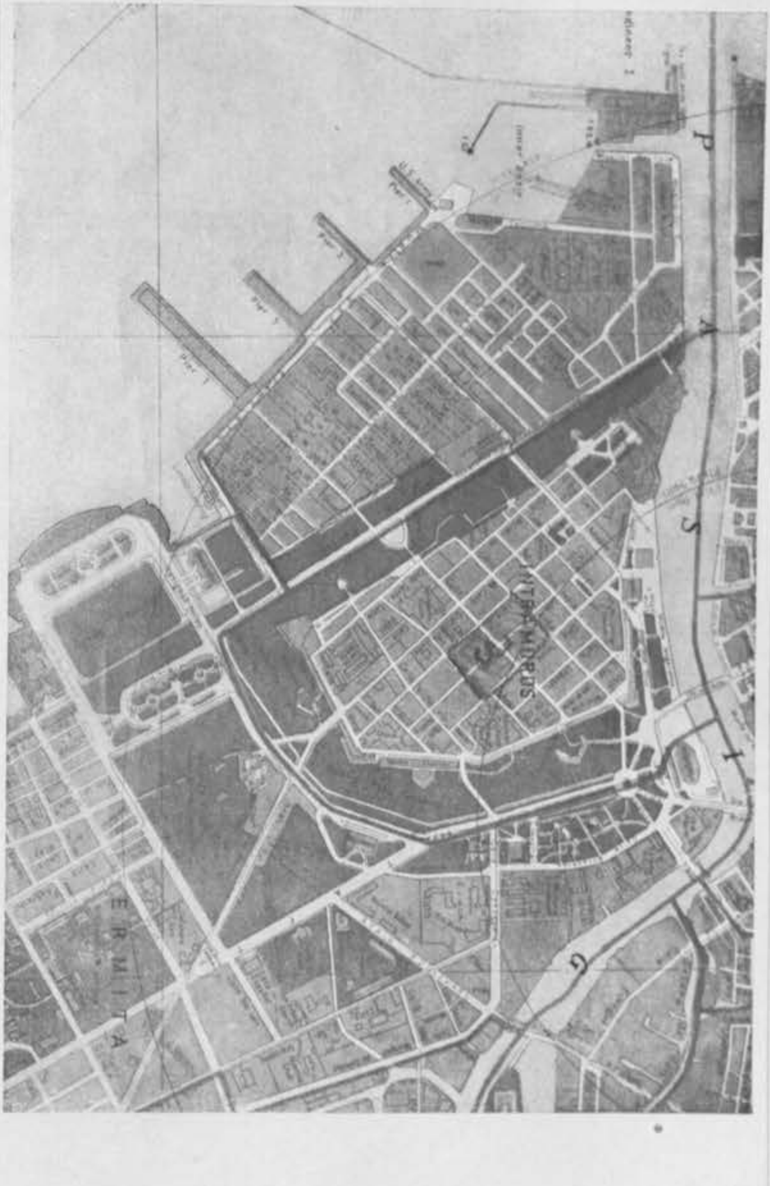


PLATE 2.

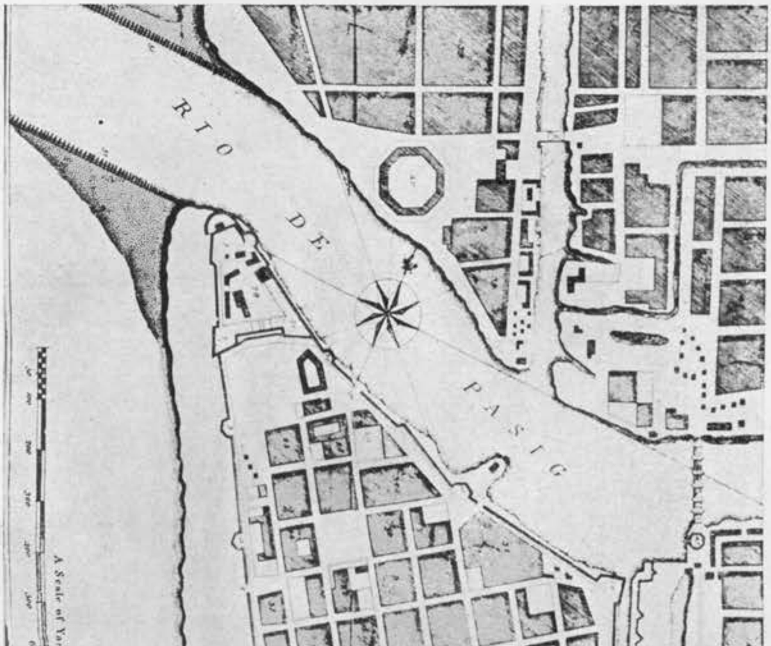


PLATE 3.

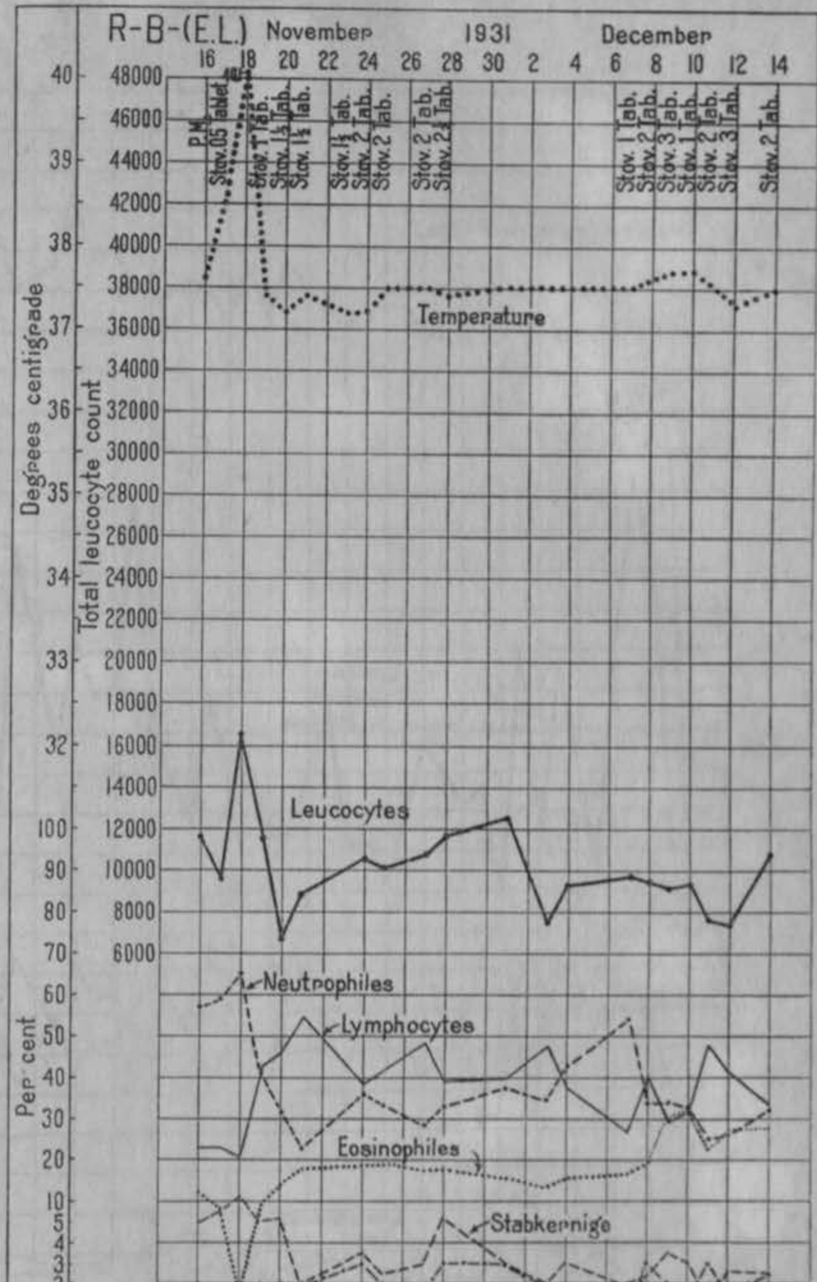


PLATE 4. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-(E.L.).

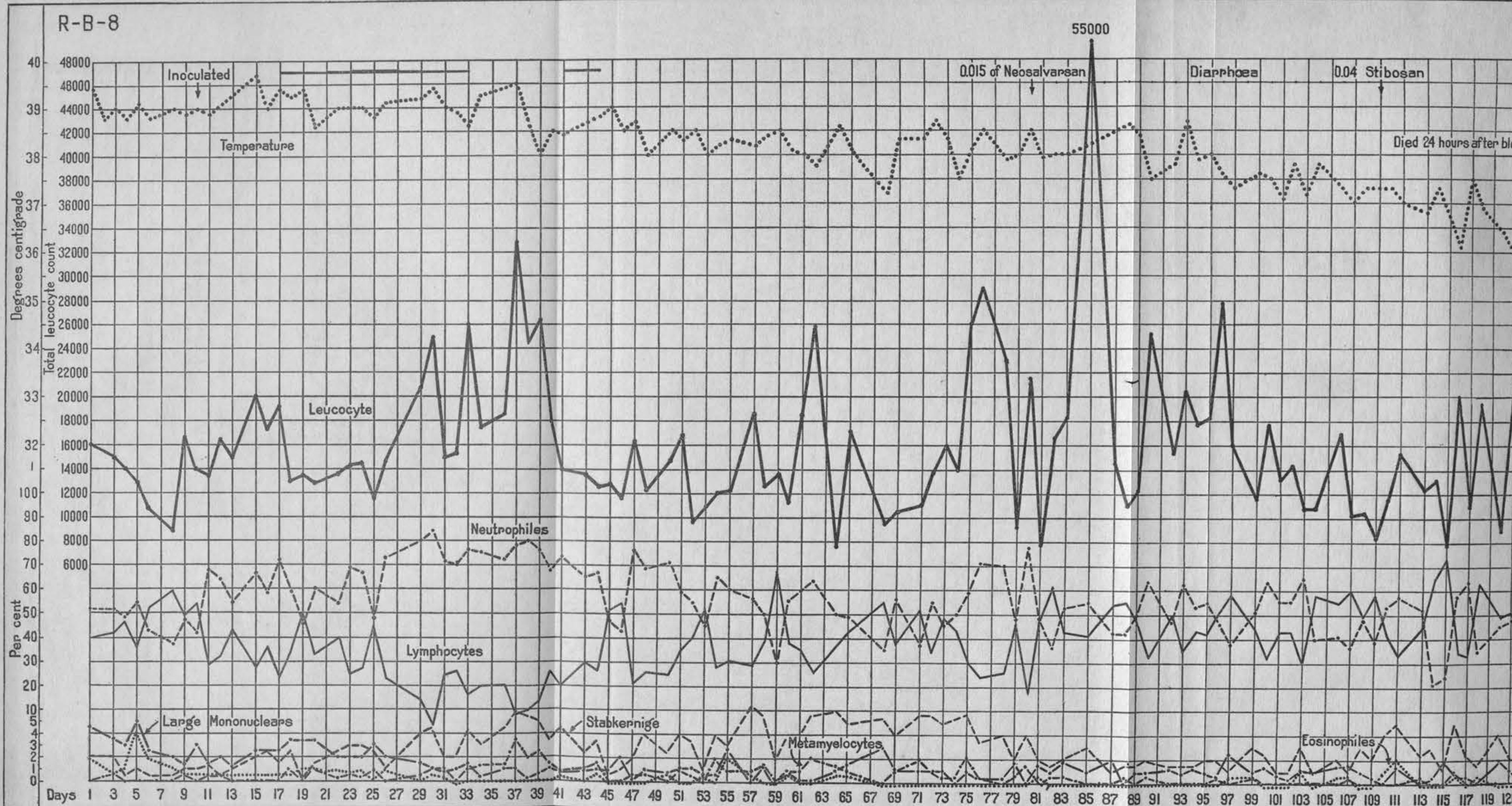


PLATE 5. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-8.

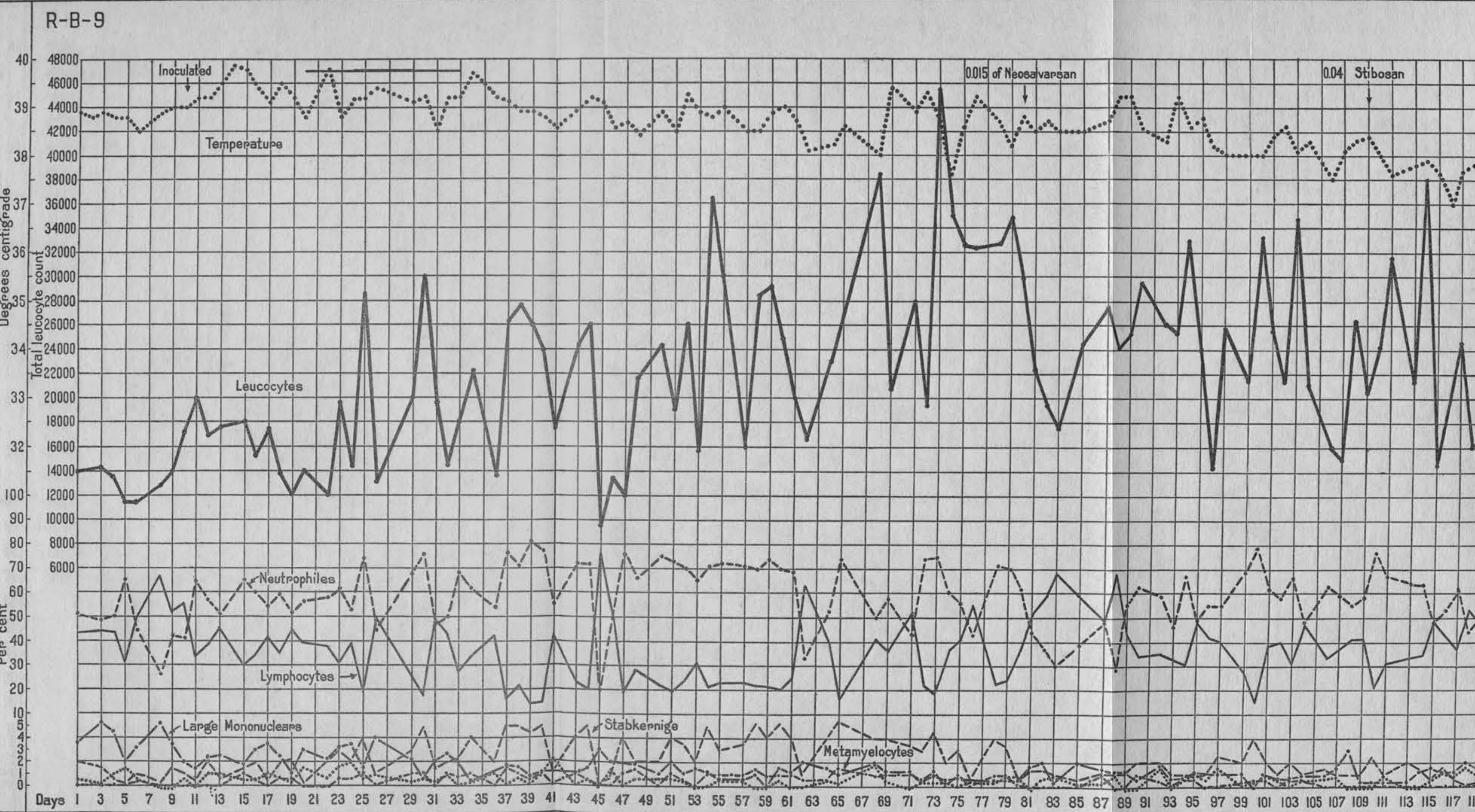


PLATE 6. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-9.

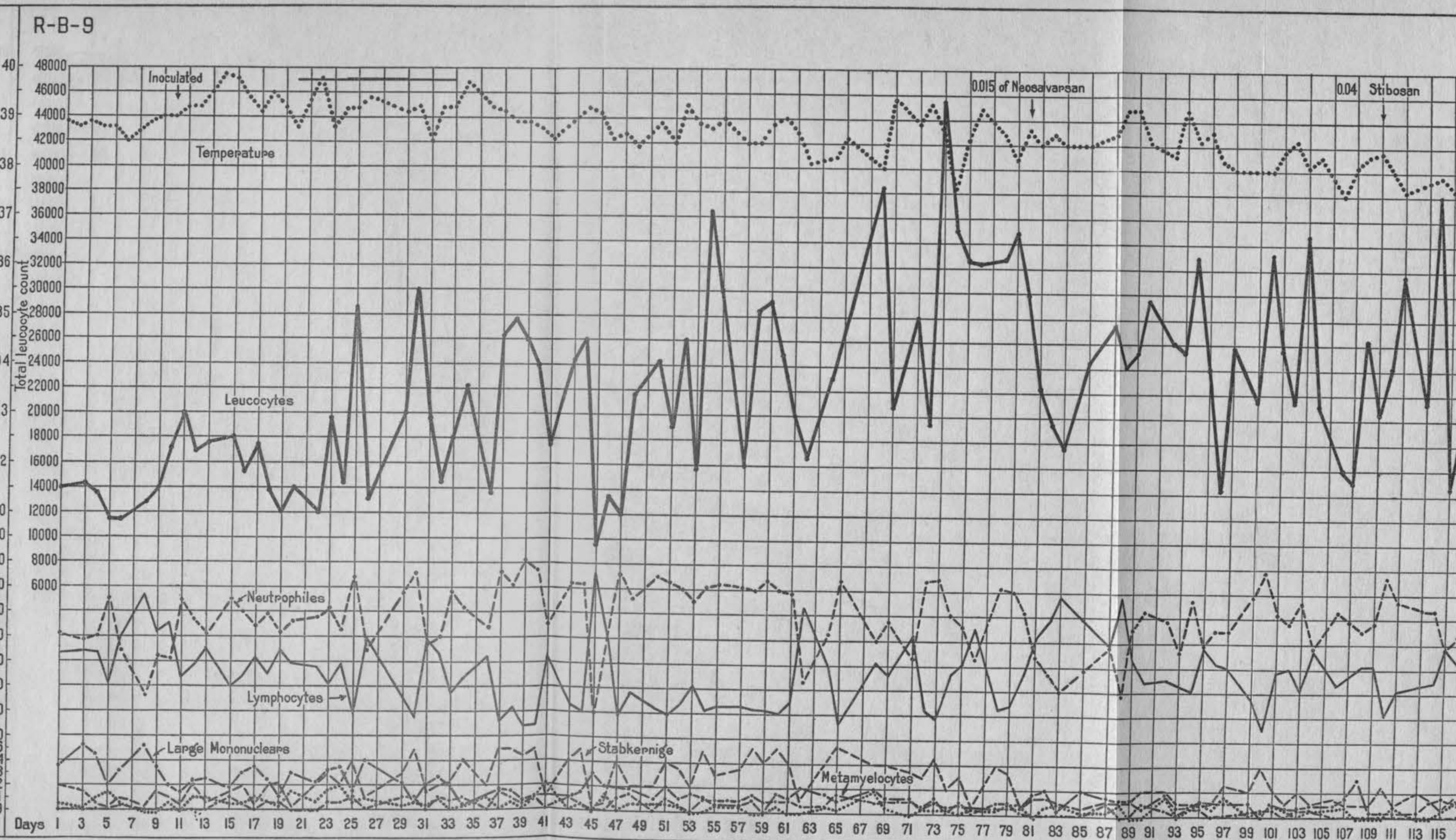


PLATE 6. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-9.

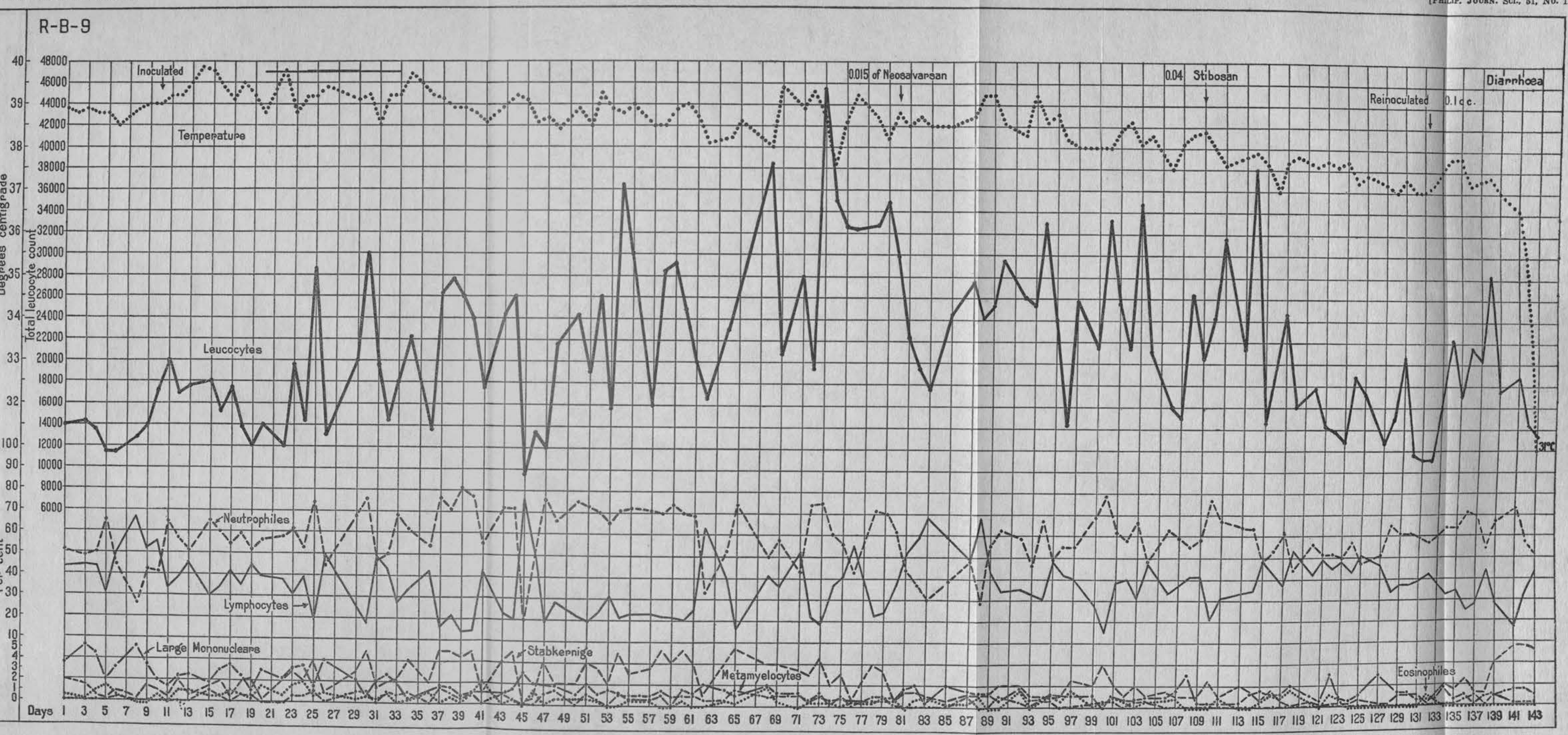


PLATE 6. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-9.

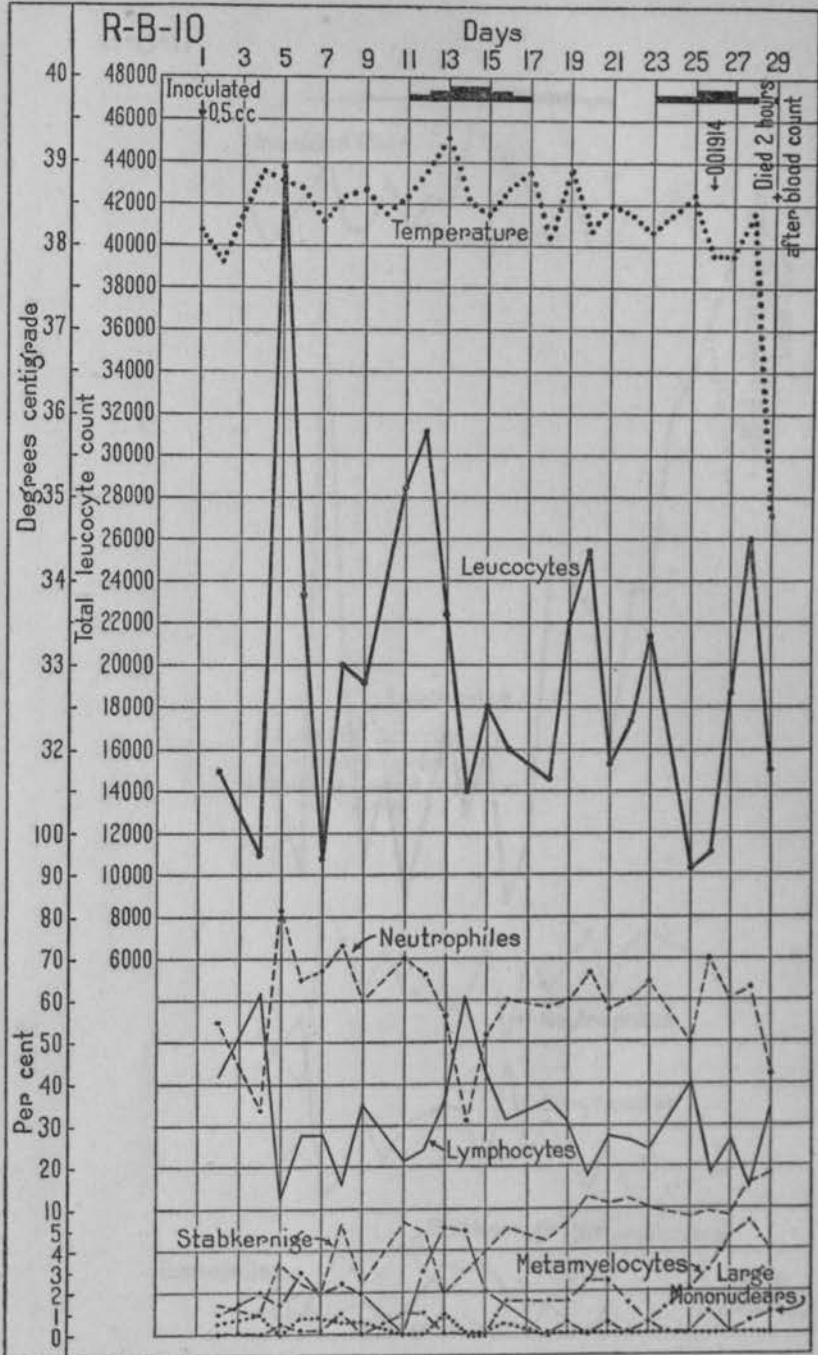


PLATE 7. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-10.

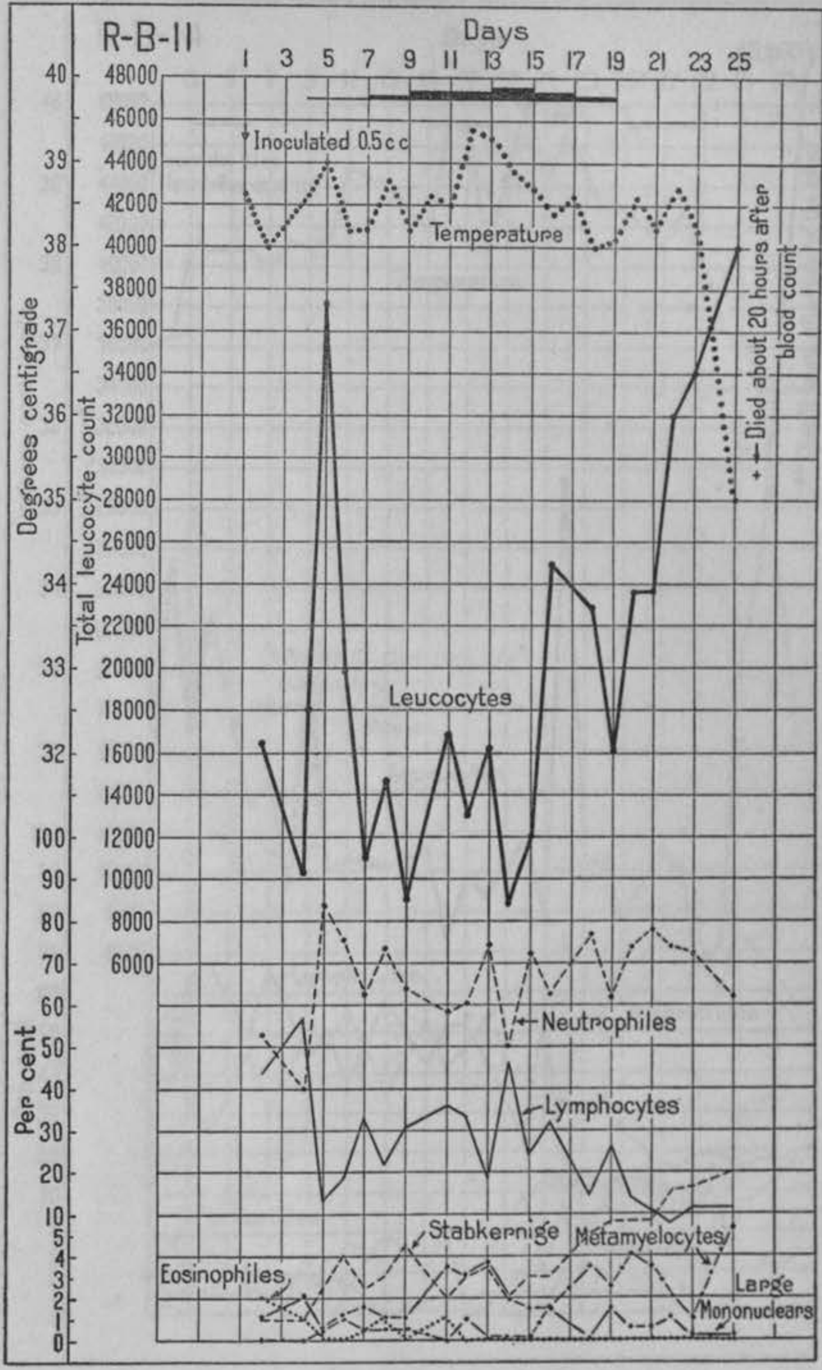


PLATE 8. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-11.

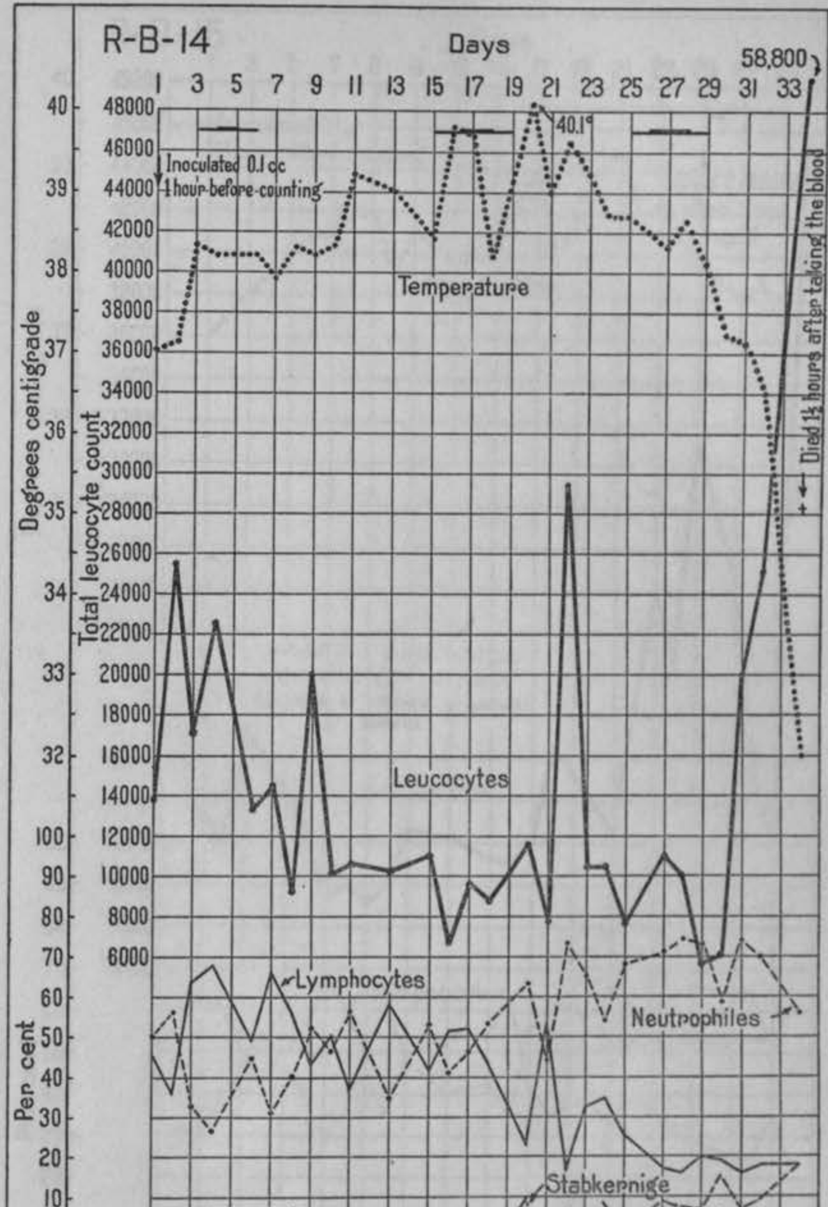


PLATE 9. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-14

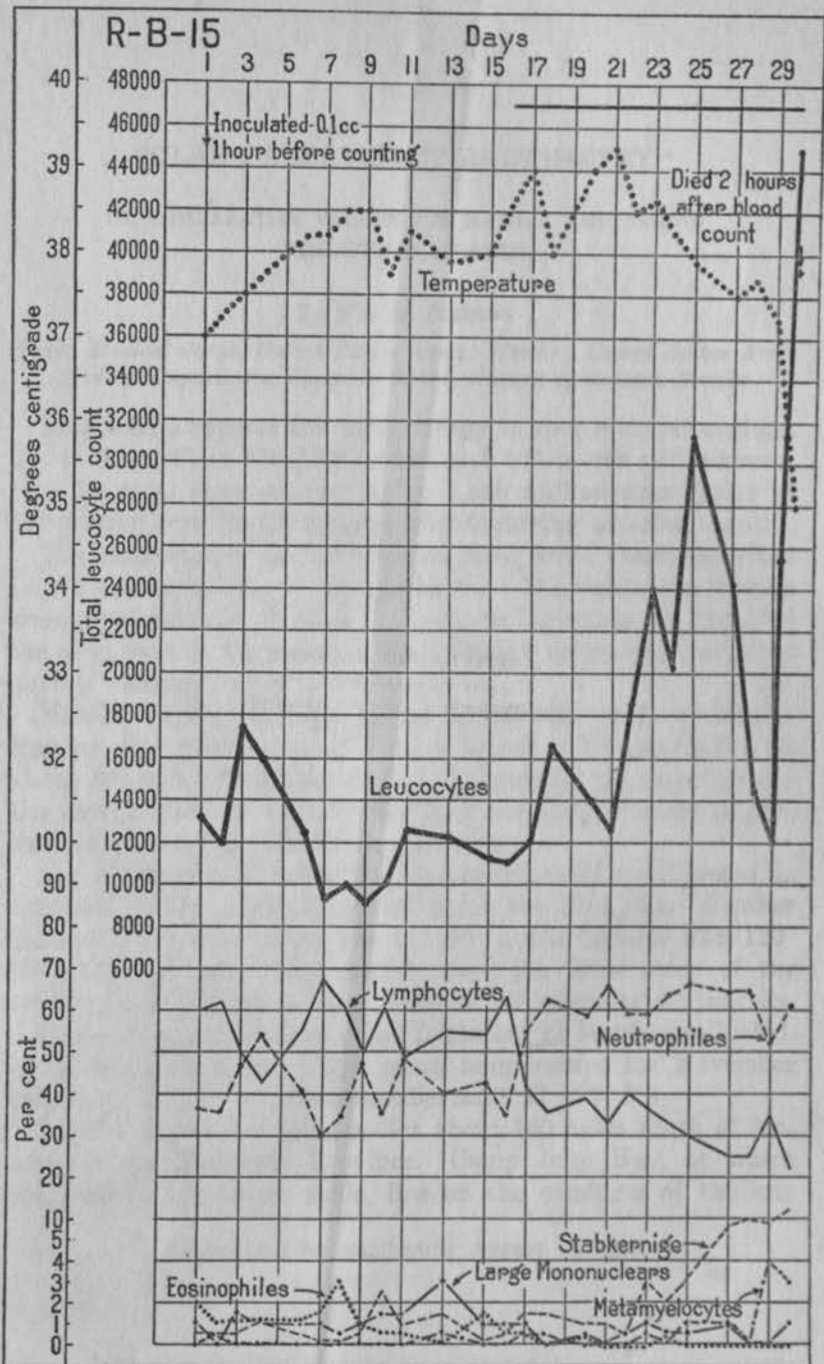


PLATE 10. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-15.

SOLAR ULTRAVIOLET RADIOMETRY *

III, COMPARATIVE VALUES FOR MANILA AND BAGUIO PHILIPPINE ISLANDS

By WM. D. FLEMING

Major, Medical Corps, United States Army; Member, United States Army Medical Department Research Board, Bureau of Science, Manila

This article reports the solar energy in four spectral regions, 290 to 310, 310 to 370, 370 to 400, and 400 to 460 millimicrons, and the total solar energy up to 1,400 millimicrons found at two localities in the Philippine Islands during adjacent months.

The instruments and procedures used were those described in the second article of this series.(1) The values for Manila were obtained from October 31, 1931, to December 23, 1931, for the most part in December, 1931. Baguio values were obtained during January, 1932.

Manila, Philippine Islands, lies on the east shore of Manila Bay on the west coast of Luzon Island. The population is about 350,000. The majority of the streets are unpaved and the combination of horse-drawn and automobile traffic is productive of much dust in the dry weather.

For the Manila observations, the instruments were placed on the roof of San Jose College in which the Philippine Weather Bureau is located. This lies 14° 35′ north latitude and 120° 59′ east longitude. The roof is over the third story of the building and affords a clear view of all quarters of the sky.

The months of November and December in Manila are included in the cool season. The mean temperature for November was 25.9° C. (78° F.), for December 24.9° C. (77° F.).

Baguio, Philippine Islands, lies about 160 miles north of Manila, in the Mountain Province. Camp John Hay, at which the observations were made, lies on the outskirts of the city

* Submitted for publication August 11, 1932.

at an elevation of 4,800 feet above sea level and at 16° 24′ north latitude and 120° 37′ east longitude. There is very little traffic through the post and most of this is on paved roads. For the month of January, 1932, the temperature ranged during the day from 63° F. to 75° F.

The instruments for the Baguio observations were placed on the roof of the west wing of the dormitory at Camp John Hay. This was one story above the ground. A clear view was had of all quarters, except on the west where a high ridge about one hundred yards away cut off the sun at about 4.30 in the afternoon.

The means of values obtained throughout the periods reported are given in Tables 1 to 5. These tables give (*a*) morning sun values, (*b*) afternoon sun values, (*c*) values for the day as a whole; that is, values for air mass 1.3 for morning are grouped with values for afternoon air mass 1.3. Values are tabulated according to air mass rather than time of day and are given both in percentages of the total energy present between λ 290 and 1,400 millimicrons and in microwatts per square millimeter of surface. Under the heading "AD" is given the deviation of the mean for the value immediately above. This is shown to give some indication of how much variation there was in the light. Under the heading "Ratio $\frac{B}{M}$" is given the ratio of the values obtained in Baguio to the corresponding finding in Manila.

DISCUSSION

The present study is limited to a comparison between the sunlight of the two places at as nearly the same time as possible; namely, adjacent months. No attempt will be made, therefore, to discuss variations of the light as a function of the time of year. The two periods fall roughly equally on either side of the winter solstice, and the weather was stable in both places.

COMPARATIVE ENERGY VALUES

Only a few published values for solar ultraviolet energy are available in the Philippines. Forsythe and Christison(2) have published calculated values for solar energy below λ 310 millimicrons. Reduced to the units used in this work, microwatts

per square millimeter, they give the following for various air masses at Cleveland, Ohio:

Air mass	1.0	1.07	1.5	2.37
Microwatts per square millimeter	0.29	0.20	0.061	0.0041

Coblentz, on the other hand, using a filter method somewhat similar to that of the present work, finds much higher values for this same region below λ 310 millimicrons. For an air mass of 1.09 in Washington, D. C., in June, he(3) found 0.90 microwatts per square millimeter. For the same place in November and December for air masses of about 2.4, his values are(4) from 0.08 to 0.22 microwatts per square millimeter; and in February, for air mass 1.75 he found 0.33 microwatts per square millimeter. At a higher altitude at Flagstaff, Arizona, 7,250 feet elevation, in September, he found about 0.75 microwatts per square millimeter for air masses about 1.20. These values are of the same order of magnitude as those reported in the present work.

As far as either the Washington figures of Coblentz or the Manila figures go, no evidence appears of an excessive amount of ultraviolet below 310 millimicrons in Manila. No closer comparison will be attempted at the present time.

RELATIVE VALUES FOR MANILA AND BAGUIO

This relation is shown under the heading "Ratio $\frac{B}{M}$." in Tables 1 to 5. From this ratio in Tables 1, 2, and 3, it is apparent that the three ultraviolet components constituted a greater portion of the total sunlight in Baguio than in Manila. This difference is especially marked in the extreme ultraviolet.

In the case of the band on the limit of the visible λ 400 to 460 millimicrons, Table 4 shows that both places possessed about equal percentages.

Table 5 shows that the total amount of energy was uniformly higher in Baguio. This has the effect of still further increasing the $\frac{B}{M}$ ratio for the actual energy present in the three ultraviolet bands. The finding of a greater amount of sunlight energy in Baguio was, of course, to be expected on account of the elevation of the place.

TABLE 1.—*290 to 310 millimicrons.*

A. MORNING SUN.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	0.058	0.074	0.064	0.056	0.061	0.052	0.061	0.035	0.040	0.030	0.053
AD ±	0.005	0.003	0.004	0.004	0.005	0.005	0.005	-------	0.002	0.002	0.004
Manila	0.034	0.029	0.023	0.017	0.018	0.021	0.027	0.021	0.010	0.004	0.020
AD ±	0.008	0.005	0.007	0.006	0.005	0.008	-------	0.008	0.003	0.002	0.006
Ratio $\frac{B}{M}$	1.7	2.6	2.8	3.2	3.4	2.5	2.3	1.7	4.0	7.5	2.6
	Microwatts per square millimeter.										
Baguio	0.60	0.78	0.65	0.56	0.59	0.53	0.58	0.35	0.39	0.27	0.53
AD ±	0.05	0.03	0.03	0.04	0.06	0.15	0.05	-------	0.03	0.02	0.05
Manila	0.28	0.30	0.27	0.13	0.13	0.08	0.21	0.10	0.06	0.03	0.16
AD ±	0.07	0.07	0.05	0.07	0.04	0.03	-------	0.09	0.02	0.02	0.05
Ratio $\frac{B}{M}$	2.1	2.6	2.4	4.3	5.0	6.7	2.8	3.5	6.5	9.0	3.3

B. AFTERNOON SUN.

	Air mass.												
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	0.059	0.076	0.069	0.066	0.063	0.061	0.055	0.006	0.051	0.030	0.018	-------	0.056
AD ±	0.003	0.005	0.004	0.006	0.012	0.007	0.012	-------	0.005	0.002	0.003	-------	0.004
Manila	0.045	0.015	0.045	0.032	-------	0.036	-------	-------	0.010	0.009	0.015	0.004	0.023
AD ±	-------	0.001	0.019	0.007	-------	0.015	-------	-------	0.005	0.004	0.004	0.002	0.008
Ratio $\frac{B}{M}$	1.3	7.6	1.7	2.0	-------	1.7	-------	-------	5.1	3.3	1.2	-------	2.2

	Microwatts per square millimeter.												
Baguio	0.61	0.76	0.67	0.65	0.61	0.58	0.52	----	0.41	0.24	0.11	----	0.62
AD ±	0.06	0.06	0.05	0.06	0.11	0.07	0.11	----	0.05	0.03	0.02	----	0.06
Manila	0.38	0.09	0.28	0.24	----	0.45	----	0.43	0.06	0.08	0.10	0.02	0.22
AD ±	----	0.06	0.22	0.07	----	0.13	----	----	0.03	0.03	0.02	0.01	0.06
Ratio $\frac{B}{M}$	1.6	8.4	2.4	2.7	----	1.3	----	----	6.9	3.0	1.1	----	2.4

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	0.058	0.074	0.066	0.059	0.062	0.055	0.058	----	0.044	0.030	0.056
AD ±	0.003	0.003	0.004	0.004	0.005	0.004	0.006	----	0.003	0.002	0.004
Manila	0.036	0.027	0.029	0.025	----	0.027	----	0.031	0.010	0.008	0.024
AD ±	0.007	0.006	0.007	0.005	----	0.007	----	0.010	0.003	0.003	0.006
Ratio $\frac{B}{M}$	1.7	2.7	2.3	2.4	----	2.0	----	----	4.4	3.8	2.3
	Microwatts per square millimeter.										
Baguio	0.61	0.78	0.66	0.58	0.60	0.54	0.55	----	0.39	0.26	0.55
AD ±	0.04	0.03	0.03	0.04	0.05	0.04	0.05	----	0.03	0.02	0.04
Manila	0.29	0.23	0.27	0.20	----	0.26	----	0.19	0.06	0.07	0.20
AD ±	0.06	0.07	0.06	0.05	----	0.09	----	0.08	0.02	0.02	0.06
Ratio $\frac{B}{M}$	2.1	2.8	2.3	2.9	----	2.0	----	----	6.9	3.7	2.7

TABLE 2.—*310 to 370 millimicrons.*

A. MORNING SUN.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	2.0	1.8	1.7	1.7	1.6	1.6	1.4	0.015	1.2	0.8	1.5
AD ±	0.0	0.2	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1
Manila	1.8	1.4	1.4	1.5	1.3	1.2	1.5	1.1	0.8	0.4	1.2
AD ±	0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.2	0.1
Ratio $\frac{B}{M}$	1.2	1.3	1.2	1.1	1.2	1.3	0.9	1.4	1.5	2.0	1.3
	Microwatts per square millimeter.										
Baguio	20.9	18.5	17.6	16.5	15.5	15.1	12.9	14.2	11.0	7.4	15.0
AD ±	0.1	0.2	0.4	0.5	0.9	0.3	0.5		0.3	0.2	0.4
Manila	15.7	14.1	11.4	13.3	9.8	7.4	11.8	6.8	5.7	1.7	9.8
AD ±	0.7	0.5	0.7	1.7	1.1	2.5		2.1	0.3	0.0	1.0
Ratio $\frac{B}{M}$	1.3	1.3	1.5	1.4	1.6	2.0	1.1	2.1	1.9	4.3	1.5

B. AFTERNOON SUN.

	Air mass.												
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	1.9	1.9	1.7	1.5	1.6	1.4	1.3		1.1	0.8	0.5		1.4
AD ±	0.0	0.1	0.1	0.1	0.1	0.0	0.1		0.1	0.1	0.1		0.1
Manila	1.7	1.7	1.5	1.6		1.3		0.8	1.0	0.5	0.4	0.1	1.2
AD ±	0.0	0.1	0.1	0.2		0.1			0.1	0.1	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.1	1.1	1.1	0.9		1.1			1.1	1.6	1.3		1.2

	Microwatts per square millimeter.												
Baguio	19.7	17.2	16.9	15.1	15.5	13.1	....	....	9.9	6.5	8.9	....	13.6
AD ±	0.1	0.2	0.4	0.3	0.5	0.4	....	....	0.3	0.4	0.3	....	0.8
Manila	13.6	13.1	10.9	11.1	....	9.8	....	6.1	6.6	3.2	2.4	0.3	8.5
AD ±	0.0	3.0	1.0	0.9	....	0.8	....	....	0.8	0.4	0.2	0.2	0.8
Ratio $\frac{B}{M}$	1.5	1.3	1.6	1.5	....	1.3	....	....	1.5	2.0	3.7	....	1.6

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	2.0	1.8	1.7	1.6	1.6	1.5	1.4	....	1.2	0.8	1.5
AD ±	0.2	0.1	0.1	0.1	0.1	0.3	0.1	....	0.1	0.1	0.1
Manila	1.7	1.6	1.4	1.6	....	1.3	....	1.0	0.9	0.4	1.3
AD ±	0.1	0.1	0.1	0.1	....	0.1	....	0.1	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.2	1.1	1.2	1.0	....	1.2	....	....	1.3	2.0	1.2
	Microwatts per square millimeter.										
Baguio	20.4	18.2	17.3	16.1	15.7	14.6	12.7	....	10.6	7.1	14.7
AD ±	0.3	0.3	0.3	0.4	0.5	0.3	0.3	....	0.2	0.2	0.3
Manila	15.5	13.1	11.2	12.0	....	8.6	....	6.7	6.0	2.9	9.5
AD ±	0.7	0.5	0.6	0.9	....	1.1	....	1.6	0.3	0.4	0.8
Ratio $\frac{B}{M}$	2.1	1.4	1.6	1.3	....	1.7	....	....	1.8	2.4	1.6

TABLE 3.—*370 to 400 millimicrons.*

A. MORNING SUN.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	3.2	3.1	3.0	2.9	2.8	2.5	2.7	2.5	2.3	2.1	2.7
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--------	0.1	0.1	0.1
Manila	2.7	2.7	2.8	2.5	2.7	2.1	2.4	2.1	2.5	1.9	2.4
AD ±	0.2	0.1	0.1	0.1	0.2	0.4	--------	0.0	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.2	1.1	1.1	1.2	1.0	1.2	1.1	1.2	0.9	1.1	1.1
	Microwatts per square millimeter.										
Baguio	32.2	32.0	31.0	29.9	27.1	26.1	25.3	25.8	22.6	18.1	27.0
AD ±	0.9	0.3	0.5	0.5	1.0	1.0	0.8	--------	0.4	0.5	0.6
Manila	23.4	24.1	22.5	23.0	19.9	23.2	19.0	12.3	18.0	9.1	19.5
AD ±	1.1	0.8	0.9	1.4	0.8	2.2	--------	3.2	0.2	1.3	1.2
Ratio $\frac{B}{M}$	1.4	1.3	1.4	1.3	1.4	1.1	1.3	2.1	1.2	2.0	1.4

B. AFTERNOON SUN.

	Air mass.												
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	3.3	2.9	3.1	2.9	2.9	2.9	2.4	--------	2.5	2.2	1.0	--------	2.6
AD ±	0.1	0.1	0.1	0.1	0.0	0.1	0.0	--------	0.1	0.2	0.2	--------	0.1

	Microwatts per square millimeter.												
Baguio	34.4	31.2	31.6	28.4	28.1	26.7	23.2		21.5	16.1	8.9		25.0
AD ±	0.2	1.0	0.5	0.5	0.3	0.2	0.1		0.8	0.7	0.3		0.5
Manila	24.4	21.0	23.3	18.4		16.3		12.1	11.4	8.6	5.0	1.4	15.6
AD ±	0.0	2.5	3.0	1.9		1.0			1.1	1.2	0.7	0.5	1.2
Ratio $\frac{B}{M}$	1.4	1.5	1.4	1.5		2.4			1.9	1.9	1.9		1.6

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	3.2	3.0	3.1	2.9	2.8	2.6	2.5		2.4	2.2	2.7
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1
Manila	2.7	2.8	2.8	2.5		2.1		2.0	2.2	1.4	2.3
AD ±	0.1	0.1	0.1	0.1		0.2		0.1	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.2	1.1	1.1	1.2		1.2			1.1	1.6	1.2
	Microwatts per square millimeter.										
Baguio	33.1	31.8	31.2	29.5	27.5	26.3	24.4		22.2	17.3	27.0
AD ±	0.5	0.3	0.4	0.4	0.5	0.7	0.5		0.3	0.4	0.4
Manila	23.5	22.2	22.7	20.3		20.2		12.3	15.6	8.7	18.2
AD ±	0.9	0.9	1.0	1.3		1.6		2.1	1.0	1.0	1.2
Ratio $\frac{B}{M}$	1.0	1.4	1.4	1.5		1.3			1.4	2.0	1.5

TABLE 4.—*400–460 millimicrons.*

A. MORNING SUN.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	9.5	8.9	8.8	8.5	8.6	8.8	8.5	9.3	8.0	7.2	8.6
AD ±	0.1	0.1	0.1	0.1	0.1	0.2	0.2	--------	0.1	0.1	0.1
Manila	9.9	9.9	9.1	10.5	8.4	10.2	8.2	9.0	8.9	6.2	9.0
AD ±	2.2	0.2	0.2	0.5	0.5	1.4	--------	0.1	0.2	0.1	0.6
Ratio $\frac{B}{M}$	1.0	0.9	1.0	0.8	1.0	0.9	1.0	1.0	0.9	1.2	1.0
	Microwatts per square millimeter.										
Baguio	99.0	89.0	90.0	85.0	84.0	88.0	78.0	92.0	78.0	69.0	85.0
AD ±	2.0	1.0	2.0	1.0	3.0	1.0	2.0	--------	1.0	1.0	2.0
Manila	84.0	80.0	73.0	87.0	65.0	73.0	65.0	52.0	64.0	30.0	67.0
AD ±	3.1	2.1	3.2	4.6	5.0	5.6	--------	13.0	2.0	3.6	5.0
Ratio $\frac{B}{M}$	1.2	1.1	1.2	1.0	1.3	1.2	1.2	1.8	1.2	2.3	1.3

B. AFTERNOON SUN.

	Air mass.												
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	9.1	8.7	8.5	8.6	8.6	8.7	8.4	--------	8.1	6.8	5.5	--------	8.1
AD ±	0.01	0.3	0.1	0.2	0.3	0.4	0.2	--------	0.1	0.2	0.3	--------	0.3
Manila	10.9	7.2	9.3	10.6	--------	8.9	--------	10.5	9.0	7.1	6.2	3.5	8.8
AD ±	0.0	1.8	0.5	0.2	--------	2.0	--------	--------	0.7	0.2	0.3	0.4	0.7
Ratio $\frac{B}{M}$	0.8	1.2	0.9	0.8	--------	1.0	--------	--------	0.9	1.0	0.9	--------	0.9

	Microwatts per square millimeter.												
Baguio	94.0	86.0	85.0	85.0	84.0	82.0	79.0		72.0	59.0	36.0		76.0
AD ±	4.0	3.0	1.0	2.0	4.0	2.0	2.0		2.0	2.0	2.0		2.0
Manila	96.0	78.0	72.0	75.0		77.0		69.0	55.0	41.0	34.0	12.1	66.0
AD ±	0.0	6.0	9.0	6.0		12.0			3.0	4.0	2.0	3.0	5.0
Ratio $\frac{B}{M}$	1.0	1.1	1.2	1.1		1.1			1.3	1.4	1.1		1.2

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	9.3	8.8	8.7	8.6	8.6	8.5	8.4		8.1	7.1	8.4
AD ±	0.1	0.1	0.1	0.1	0.1	0.2	0.1		0.1	0.1	0.2
Manila	10.0	9.4	9.2	10.5		10.6	8.2	9.4	8.9	6.9	9.2
AD ±	0.2	0.2	0.2	0.2		1.2		0.4	0.8	0.2	0.4
Ratio $\frac{B}{M}$	0.9	0.9	0.9	0.8		0.8			0.9	1.0	0.9
	Microwatts per square millimeter.										
Baguio	97.0	89.0	89.0	85.0	84.0	87.0	79.0		76.0	65.0	83.0
AD ±	2.0	1.0	1.0	1.0	3.0	1.0	2.0		1.0	1.0	1.0
Manila	88.0	75.0	73.0	80.0		75.0	65.0	56.0	61.0	38.0	68.0
AD ±	3.0	2.2	3.2	3.9		6.0		10.0	1.0	4.0	4.0
Ratio $\frac{B}{M}$	1.1	1.2	1.2	1.1		1.2			1.3	1.7	1.2

TABLE 5.—*290 to 1,400 millimicrons.*

A. MORNING SUN.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	Microwatts per square millimeter.										
Baguio	1,042	1,040	1,023	1,003	981	1,021	944	995	960	914	992
AD ±	5	4	10	20	29	7	19	--------	8	9	12
Manila	841	832	802	868	767	845	793	577	729	490	754
AD ±	17	13	16	14	24	87	--------	204	6	61	44
Ratio $\frac{B}{M}$	1.2	1.3	1.3	1.2	1.3	1.2	1.2	1.2	1.7	1.9	1.3

B. AFTERNOON SUN.

	Air mass.												
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	Microwatts per square millimeter.												
Baguio	1,040	999	1,013	995	974	943	952	--------	900	811	685	--------	931
AD ±	18	12	4	30	8	16	12	--------	11	11	28	--------	15
Manila	873	764	774	713	--------	733	--------	714	639	565	559	314	703
AD ±	0	49	80	66	--------	49	--------	--------	38	43	22	45	44
Ratio $\frac{B}{M}$	1.2	1.3	1.3	1.4	--------	1.3	--------	--------	1.4	1.5	1.2	--------	1.3

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	Microwatts per square millimeter.										
Baguio	1,041	1,032	1,019	1,001	978	992	950	------	943	873	981
AD ±	6	4	6	13	17	11	12	------	9	12	10
Manila	845	824	795	775	------	789	793	611	697	539	741
AD ±	15	13	19	38	------	30	------	104	15	16	31
Ratio $\frac{B}{M}$	1.2	1.3	1.3	1.3	------	1.3	------	------	1.4	1.6	1.3

Freer and Gibbs(5) reported a comparison of Manila and Baguio sunlight in 1912. They used the uranyl-oxalic acid method, which was discussed in the first paper of this series.(1) The reaction is activated most strongly by light of about λ 310 millimicrons, though it is affected by all of the solar ultraviolet. For the months of March, April, May, and June, 1911, in Baguio they found a mean of 14.2 per cent of oxalic acid decomposed per hour, while in Manila a mean of 13.6 per hour was decomposed for the same months. This gives a ratio $\frac{B}{M} = 1.05$. Taking the mean of results in Manila from May, 1910, to July, 1911, as 12.5 per cent, the $\frac{B}{M}$ ratio of 1.14 was obtained. The values in Baguio were probably decreased by the low figure for July due, presumably, to cloudy weather. Further, the values represent a wider spectral region than any one of the three ultraviolet regions reported in the present work, probably representing nearly the sum of all three regions. However, after allowance is made for all these considerations, the ratio $\frac{B}{M}$ appears much lower than those now reported.

VARIABILITY OF LIGHT

Under the heading "AD" the tables give the deviation of the mean of the tabulated values.

$$AD = \frac{a.d.}{\sqrt{n}} \text{ where } a.d. = \frac{\Sigma d}{n} \text{ and}$$

d = difference between individual value and the mean
n = number of observations.

Using this quantity AD as an indication of the variability of the light it is seen from the tables that the light in Manila was much more variable than in Baguio. This is particularly marked in the values for total energy.

RATIO OF MORNING LIGHT TO AFTERNOON LIGHT

There is a common belief in Manila that the morning light is much stronger than that of the afternoon, especially in its burning effects. Persons swimming or playing tennis or golf in the afternoon on week days without sunburn are apt to report sunburn after a Sunday morning exposure. To examine this the ratios of morning sun to afternoon sun have been compiled in Table 6. In this are given the means of the ratio

morning sun to afternoon sun obtained for all the different air masses studied. These means are grouped in three different ways, as follows:

(*a*) The mean of values for all air masses 1.2 to 3.

(*b*) The mean of values for air masses 1.2 to 1.5, inclusive. This included for Manila from about 9.30 a. m. to 12 noon and 12 noon to about 2 p. m., for Baguio from 10 a. m. to 12 noon and from 12 noon to about 2 p. m.

(*c*) The mean of values for air masses 1.6 to 3, inclusive. This included morning hours before and afternoon hours after those of (*b*).

TABLE 6.—*Mean values of the ratio Morning sun to Afternoon sun.*

Millimicrons.	Air mass. Manila.					
	1.2–3.0	1.2–1.5	1.6–3.0	1.2–3.0	1.2–1.5	1.6–3.0
	Per cent.	*Per cent.*	*Per cent.*	*Microwatts.*	*Microwatts.*	*Microwatts.*
290–310	0.82	0.94	0.67	1.01	1.39	0.62
310–370	0.90	0.94	0.84	0.95	1.12	0.72
370–400	1.12	1.03	1.22	1.19	1.08	1.29
400–460	1.02	1.07	0.93	0.97	1.04	0.90
290–1,400	....	....	....	1.04	1.08	1.00
Millimicrons.	**Air mass. Baguio.**					
	1.2–3.0	1.2–1.5	1.6–3.0	1.2–3.0	1.2–1.5	1.6–3.0
	Per cent.	*Per cent.*	*Per cent.*	*Microwatts.*	*Microwatts.*	*Microwatts.*
290–310	0.92	0.90	0.94	0.98	0.92	1.02
310–370	1.04	1.04	1.03	1.09	1.07	1.10
370–400	0.98	1.00	1.21	1.02	1.00	1.04
400–460	1.02	1.02	1.01	1.05	1.04	1.06
290–1,400	....	....	....	1.04	1.01	1.05

For the total energy (290 to 1400 millimicrons) at both Manila and Baguio, the differences between morning and afternoon sun are very small and insignificant. In the case of Baguio this same relation holds for all four of the spectral fractions investigated.

In Manila, however, two instances of marked difference between morning and afternoon light appear. For air mass 1.2 to 1.5 (that is, from about 10 a. m. to noon and from noon to

about 2 p. m.) the morning light in actual energy present exceeds the afternoon light in the ratio of 1.39 for the band λ 290 to 310 millimicrons and in the ratio of 1.12 for the band λ 310 to 370 millimicrons. Since the production of erythema is due largely to light of wavelength peaked narrowly about λ 310 millimicrons, this should explain the more-marked burning effect of the morning sun.

This apparent difference is probably enhanced by the hours of customary sun exposure as governed by living conditions in Manila. Recreation on Sunday morning is apt to be taken between 10 o'clock and noon rather than earlier. On the other hand, afternoon sports usually occur after the siesta or office hours, after 3 o'clock, if not later. The popular impression, therefore, is due partly to the morning exposure being to sunlight through an air mass less than 1.5, while the afternoon exposure is to sun through an air mass exceeding 1.5. Nevertheless, there does appear to be a greater amount of energy capable of causing erythema in the morning light.

The only explanation of this that can be offered at present is the greater opacity of the lower atmosphere in the afternoon due to traffic in the city beating up a dust cloud with possibly sufficient carbon monoxide from automobile engines to aid in a selective absorption. The dust settles during the night, and the carbon monoxide, if a factor, is dissipated. Morning traffic in Manila is fairly evenly diffused but rises to a sharp peak at 12 noon when cars running at high speed fill the streets with office workers going to lunch.

Against this explanation must be cited the statements of several persons living on Corregidor Island, in the mouth of Manila Bay, 30 miles west of the City of Manila. These persons have observed the same greater burning power of the morning sun on Corregidor and even on small boats sailing short distances west of Corregidor. This is certainly too far west of Manila to be affected by any dust due to city traffic, although here again the possibility of the hours of morning exposure being at times of air mass less than 1.5 and afternoon exposure at times of air mass greater than 1.5 must be remembered. It is planned to make a series of observations on Corregidor to see if this difference appears in values obtained instrumentally.

Earp,(6) in comparing values obtained at Boulder, Colorado, with those obtained at Baltimore, Maryland, both by the zinc

sulphide method, says, "In Baltimore there is a tendency for higher readings in the afternoon. In Boulder the typical curve appears to be that for June 30th with a maximum about 11 a. m. and a plateau of high readings in the early afternoon." The Baltimore values mentioned are apparently those obtained by Clark.(7) Neither Earp nor Clark discusses this feature further.

SUMMARY

1. No evidence of an excessive amount of ultraviolet light in Manila in December as compared with Washington, D. C., was found.

2. The amount of energy in three spectral regions in the ultraviolet was much greater in Baguio than in Manila, Philippine Islands. Light in the visible violet region was about equal for the two places. The total energy present in the sunlight was greater in Baguio than in Manila.

3. Greater variations were present in the sunlight in Manila than in Baguio.

4. Some evidence was found that morning sunlight in Manila possessed greater erythema-producing energy than the afternoon sunlight. Dust raised by city traffic is discussed as an explanation of this.

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ABSTRACT

Solar energy values for three spectral regions in the ultraviolet and one region in the violet limit of visible light are reported from the Philippine Islands, for Manila, at sea level, and for Baguio, at 4,800 feet elevation.

CHIRONOMIDÆ FROM JAPAN (DIPTERA)
I. CLUNIONINÆ [1]

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TWO PLATES

The chironomid flies discussed in this paper are entirely from the seashores of Japan, where they were collected by Prof. Dr. Hachiro Yuasa, Prof. Dr. Teizo Esaki, and by myself. I am greatly indebted to Professor Yuasa for his kind directions which made this study possible. My deepest thanks are also extended to Professor Esaki for the privilege of retaining the types of rare forms described in the following pages.

The subfamily Clunioninæ contains, at present, seven genera; namely, *Clunio* Haliday, *Eretmoptera* Kellogg, *Halirytus* Eaton, *Paraclunio* Kieffer, *Psammathiomyia* Deby, *Telmatogeton* Schiner, and *Thalassomyia* Schiner. Only two of these genera, *Clunio* and *Telmatogeton*, which are dealt with in this paper, are known from Japan, as far as I can ascertain, although it is more than probable that other genera will be found when more thorough collecting is undertaken. In the present report four marine chiromonid flies, two species and one variety of *Clunio* and one species of *Telmatogeton*, are discussed as new to science.

From the ecological point of view, *Telmatogeton* is the most interesting. Some of the flies of this genus were found in torrents of the Hawaiian Islands, and the others were found on the coasts of oceans in various parts of the world, while all the other genera of the Clunioninæ are truly marine in habitat. The Japanese flies of the genus *Telmatogeton* are also found right on the coast of the Pacific Ocean, but the curious fact is that flies of the same species found on the coast of the Japan Sea establish their colonies only on the inner side of the breakwater at the estuary. The specimens collected at the latter locality were reared to the imago stage from the larvæ en-

[1] Contribution from the entomological laboratory, Kyoto Imperial University, No. 28.

tirely in fresh water. This is an interesting fact that suggests the divergent habitats of this genus. Another interesting point is the morphological feature of the tarsal claws and their accessory structures. The ultimate tarsal joints of the two sexes of *Telmatogeton* are provided each with a pair of thin lamellæ in place of the pulvilli, and those of the male of *Clunio* each with a pair of claws which are provided with a large thin lamella on each ventral side. These modifications might have been derived from different original structures; those of *Telmatogeton* are probably homologous with the pulvilli and those of *Clunio* are probably identical with the hairs on the claw similar to those of *Pontomyia* discussed in my paper of 1932.

A certain marine chironomid fly reported as a *Paraclunio* species in my previous papers on marine insects in 1930 and 1932 is now determined as a new species of *Telmatogeton*, as will be described later.

Abbreviations used in this paper are as follows: A.R. is the antennal ratio in length between the ultimate joint and the remaining joints of the flagellum and the pedicel taken together. fCu is the cubital fork of the wing vein between M_{3+4} and Cu_1. Terminology of the wing venation used is that of the Comstock-Needham-Tillyard system and that of the head, thorax, and hypopygium used is that of the MacGillivray system modified by Tokunaga.

Key to the genera of Clunioninæ.

1. Wings normal, at least in the male .... 2.
   Wings not normal, reduced in both sexes .... 5.
2. Squamæ of the wings bare .... *Clunio* Haliday.
   Squamæ of the wings fringed .... 3.
3. Maxillary palpi segmented .... 4.
   Maxillary palpi unsegmented .... *Paraclunio* Kieffer.
4. Maxillary palpi 2-segmented .... *Telmatogeton* Schiner.
   Maxillary palpi 4-segmented .... *Thalassomyia* Schiner.
5. Antennæ 7-segmented .... *Psammathiomyia* Deby.
   Antennæ with less than seven segments .... 6.
6. Fifth tarsal segment trilobated at tip .... *Halirytus* Eaton.
   Fifth tarsal segment simple at tip .... *Eretmoptera* Kellogg.

Genus CLUNIO Haliday

Key to species of Clunio Haliday.

MALES

1. Ultimate joint of the antenna shorter than the preceding seven joints taken together .... 2.
   Ultimate joint of the antenna longer than or subequal to the preceding seven joints taken together .... 4.

2. Cu_1 slightly curved .... *C. setoensis* sp. nov.
   Cu_1 distinctly curved, recurvate........................ 3.
3. R_{4+5} shorter than twice the proximal section of M.
   C. marinus Haliday = *bicolor* Kieffer.

   R_{4+5} longer than or subequal to twice the proximal section of M.
   C. adriaticus Schiner = *balearicus* Bezzi.
4. Cu_1 distinctly curved .... 5.
   Cu_1 slightly curved .... *C. pacificus* Edwards.
5. Ultimate joint of the antenna shorter than one-half the entire length.
   C. tsushimensis sp. nov.

   Ultimate joint of the antenna subequal to or longer than one-half the entire length .... *C. tsushimensis* var. *minor* var. nov.

CLUNIO SETOENSIS sp. nov.

This fly was found among the algal matting of the rocky seashore between the tide marks of the Pacific coast at Seto. A male pupa and a male pupal skin were also collected at the same place, but the larval forms and the adult females have not been obtained.

Male.—Body about 2.1 mm in length, very scantily haired; general coloration greenish; wings milky white; head, thorax. and abdominal tip brown; legs generally pale greenish brown; scutellum pale green, with many brown setæ; mid-dorsal suture black, without setæ; pseudosutural foveæ each with several small setæ along it; supra-alar setal group represented by two small setæ.

Head round and small. Eyes oval, covered with velutinous hairs; distance between eyes less than their vertical length, this ratio being 10 : 17. Clypeus without setæ. Maxillary palpi not segmented, fingerlike, brown on the distal half, each with a few small setæ on its tip. Mouth parts greatly reduced; paraglossæ atrophied. Antennæ (Plate 1, fig. 4) without plumose setæ, 10-segmented (excepting the antennariæ); antennaria triangular in the frontal aspect, brown; scape also brown, bulbous, longer than broad, with several hyaline sensory hairs, distinctly narrowed on its proximal end; second joint pale green, brown on its distal margin, quite long, subequal in length to the following four joints taken together, with two small brown setæ on its middle part; ultimate joint somewhat spindle-shaped, distinctly narrowed on the distal part, greenish white under reflected light and pale brown under transmitted light, without setæ, but with numerous minute sensory hairs, subequal in length to the preceding four joints taken together or to the second joint; remaining eight small joints each slightly longer than broad and barrel-shaped, subequal in size and shape to

each other, pale brown on the proximal part and brown on the distal margin; two short hyaline sensory hairs arranged on the distal margin of each joint from second to ninth.

Hypopygium very large, occupying about one-third of the abdomen, turned through about 80°; penultimate sternite broad, with a somewhat U-shaped thickening, without setæ; ultimate tergite small and with about three pairs of small setæ; ultimate sternite located between the large coxites, elongated caudad, forming a large tube of penis, covered entirely with slender microtrichiæ; coxites large, firmly united to each other, immovable independently, dark brown, covered entirely with velutinous hairs; styles (Plate 2, fig. 10) triangular, folded inward, each articulated on the laterocaudal tip of the coxite, thickly covered with velutinous hairs and on the dorsal side scantily covered with slender setæ besides the velutinous hairs, on the caudal angle of the style with about eight minute teeth which are erected dorsad and on the mesal margin with a minute tooth near the cephalic angle; parameres very small, firmly united to each other on the proximodorsal side of the penis tube; apophysis slightly chitinized, located along the dorsolateral sides of the penis tube.

Lengths of leg joints.

[44 units=0.7 mm. *38 units=0.1 mm.]

Leg.	Joint.									
	Coxa.	Tro-chanter.	Femur.	Tibia.	Tarsus.					
					1st.	2d.	3d.	4th.	5th.	Total.
Fore	15	10	27	41	*50	*20	*16	*12	*30	20
Middle	10	6	35	33	*40	*18	*15	*12	*30	19
Hind	10	9	39	35	*50	*20	*27	*12	*30	22

Legs comparatively stout, general coloration pale greenish brown; coxæ, trochanters, and all the articulations of the legs more or less brown; femora of the forelegs and femora and trochanters of the posterior four legs with rows of strong setæ; tibial spurs present, one on each leg, strongly curved at tip, similar in shape and size to each other on three pairs, each with one or two small setæ before the tip, spinous on its proximal half; tarsal joints more or less bilobated on the distal end, spe-

cially distinctly lobated on the ultimate joint, which is cordiform; third tarsal joint of the hind legs constricted on the dorsal side before the distal tip. Claws large, unserrated and distinctly curved, each with a peculiar large lamella and a tuft of several hyaline setæ on its ventral side; empodium large and spinose, as large as the claws; pulvilli wanting.

Wings (Plate 1, fig. 1) slightly brown under transmitted light, 1.7 mm long, very broad, without macrotrichiæ excepting the marginal setæ; squama large and completely bare; anal angle well developed and sharp, separated from the alula by a narrow area; vein R_{4+5} almost straight, not long, subequal in length to R or about twice as long as R_1, ending on the costal margin far before the wing tip; M_{1+2} sinuous, atrophied slightly before the wing tip; fCu located slightly beyond the level of r-m and about on the middle of the wing, its two branches, M_{3+4} and Cu_1, atrophied before the wing margin; Cu_1 curved caudad slightly; 1A extending scarcely beyond the base of fCu, curved caudad at its tip and parallel to Cu_1.

Habitat.—Seashore between the tide marks, Japan.

Holotype.—Male; Seto, Wakayama Prefecture; May 20, 1927.

Paratopotypes.—Males; May 20, 1927.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University; collected by Prof. Dr. Hachiro Yuasa.

This species is closely related to *Clunio marinus* Haliday and *C. adriaticus* Schiner, especially in the structure of the antennæ, but distinctly different from these species in the structure of the wing. General shape of the wing of the related species is comparatively slenderer than in the Japanese species; vein R_{4+5} of the above two species far longer than the proximal section of M or R, ending near the wing tip, while in the present species vein R_{4+5} is very short, ending far before the wing tip, so that the distance between the tips of R_{4+5} and M_{1+2} is comparatively far greater than in the above species; moreover, vein M_{3+4} is more strongly curved in the related species than in the Japanese species. Another allied species is *C. pacificus* Edwards, but the two differ distinctly in the relative length of the antennal joints: ultimate joint of the allied species is long and fully as long as the preceding seven joints taken together, while in the Japanese species it is subequal in length to the preceding four joints taken together or to the second joint itself.

CLUNIO TSUSHIMENSIS sp. nov.

This fly has been collected at ebb-tide on the rocky seashor of Tsushima Island where the rocks are covered with sea algæ The immature forms and females have not been obtained.

Male.—Body about 1.5 mm in length and very scantily haired general coloration pale greenish brown; supra-alar setal grouj of the mesothorax represented by three small setæ; scutellun pale brown, setigerous with brownish black hairs; halteres pal green.

Head small and round. Mouth parts atrophied. Maxillary palpi not segmented, pale brown on the distal half, with twc or three minute setæ. Eyes round and covered with velutinous hairs; distance between eyes subequal in length to the vertica length of the eyes (11:10). Antennæ (Plate 1, fig. 7) 10-segmented (excepted antennariæ), without plumose hairs; antennaria triangular in the frontal aspect and brown; scape alsc brown, with several hyaline sensory setæ and longer than its diameter; pedicel generally pale green, about one and one-half times as long as the scape, with two small setæ on the distal part and brown on the distal margin; ultimate joint pale brown under refracted light, very long, twice as long as the preceding seven joints taken together or subequal to the preceding eight joints taken together; A.R. about 0.87; each joint from third to ninth pale green, shorter than its diameter and with a pair of small hyaline sensory hairs on its distal margin.

Hypopygium (Plate 2, fig. 13) very large and brown; styles (Plate 2, fig. 11) somewhat elongated, triangular, with several (5) minute teeth on the caudal corner and a small tooth on the mesal margin near the cephalomesal corner.

Relative length of the joints of the legs are shown in the following table:

Lengths of leg joints.

[44 units=0.7 mm. *38 units=0.1 mm.]

Leg.	Joint.									
	Coxa.	Trochanter.	Femur.	Tibia.	Tarsus.					
					1st.	2d.	3d.	4th.	5th.	Total.
Fore	12	7	26	36	*50	*17	*16	*13	*20	19
Middle	12	6	31	30	*35	*15	*14	*11	*20	15
Hind	12	7	34	32	*41	*18	*30	*12	*21	20

General coloration of the legs pale greenish brown; coxæ, trochanters, and all the articulations between the joints brown; tibiæ each with a spur, which is slightly curved at tip, spinose on its proximal half and without isolated setæ. Claws unserrated, distinctly curved ventrad, each with a large hyaline lamella and a tuft of hyaline setæ on its ventral side; pulvilli wanting; empodium as large as the claws.

Wings (Plate 1, fig. 2) broad; anal angle well developed and sharp; squama quite bare. Vein R_{4+5} shorter than the proximal section of M, straight, ending on the costal margin far before the wing tip; distal section of M (M_{1+2}) long, almost straight, very slightly curved upwards, ending near the wing tip, so that the distance of its tip from the tip of R_{4+5} is much greater than from the tip of M_{3+4} and equal to the length of R_{4+5}; fCu located beyond r-m; Cu_1 distinctly curved caudoproximad; 1A almost straight, only the tip curved.

Habitat.—Rocky seashore under the high tide mark, Japan.

Holotype.—Male; May 28, 1930.

Paratopotypes.—Males; May 28, 1930.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University, and in the entomological laboratory, Kyushu Imperial University; collected by Prof. Dr. Teizo Esaki.

This species is closely allied to *Clunio pacificus* Edwards and *C. setoensis* Tokunaga except in the very long ultimate joint of the antenna and distinctly recurvate Cu_1.

CLUNIO TSUSHIMENSIS var. MINOR var. nov.

This fly was very abundant in the summer season on the algal matting of the rocky seashore under the high tide mark at Seto, Wakayama, Japan. Large colonies of this fly were found generally on the level occupied by the zone of an alga, *Tubinaria (?) fusiformis* Yendo. The majority of the imagines of both sexes emerged soon after the algal matting was exposed to the air by the recession of the tide, and their swarming was often observed even under the direct sunshine. The males were running with fluttering wings or lowly skimming over the algal matting, single or in copula. Copulation is end to end in position and lasted about two or three minutes. Several males sometimes made a mass entangling with each other around one female. Eggs are laid out at one time immediately after the copulation and they are arranged in a single file in a very sticky gelatinous cord.

Immature forms, pupæ (males and females) and larvæ, are found in the tubelike nest cases built with silky threads binding the débris of algæ and diatoms. Larvæ often suspend themselves in the water by the sticky strong silky threads when they are disturbed. In one colony various stages of larvæ are found besides the pupæ and imagines at the same time.

Male.—Excepting the antennæ, the characters of the male are nearly identical with those of the typical species. Body 1 to 1.3 mm in length; coloration pale greenish brown generally. Eyes small, round, separated from each other by a distance equal to the vertical length of the eyes (10 : 9). Antennæ (Plate 1, fig. 8) 10-segmented (excepting the antennariæ); A.R. 1.03 to 1.04; second antennal joint with two small setæ on its distal part and brown on the distal margin; third to ninth joints very short, each half as long as its diameter and with a pair of small hyaline sensory hairs; ultimate joint very much elongated, more than half the length of the antenna.

Wings broad, 0.9 to 1 mm in length; milky white in life and pale brown under transmitted light.

Female.—Body yellowish white generally without conspicuous macrotrichiæ, 1 to 1.3 mm in length and with short legs. Wings absent. Head very small and round. Eyes very small, consisting of about ten facets and very widely separated from each other. Paired eyelike spots each located on the gena. Maxillary palpi greatly reduced and without setæ. Antennæ (Plate 1, fig. 9) very small, 5-segmented; antennaria reduced into uniform membrane; scape subequal in length to its diameter; pedicel with one minute seta on its middle part, shallowly constricted at the proximal part and twice as long as the scape; ultimate joint somewhat elongated but shorter than the pedicel.

On the abdomen, seventh sternite covered with minute soft hairs; eighth sternite brown, completely separated into lateral parts by the depression of the genital chamber; ninth segment membranous and somewhat elongated; paraprocts very small, contiguous, located between the cerci; spermatothecæ two, oval, brown, their ducts also brown; cerci (Plate 2, fig. 12) small, not pointed caudad but somewhat produced ventrad and very scantily haired.

Tibial spurs completely wanting; claws dark brown, each with one to two minute setæ on the ventral side and without lamella; empodium very short, hardly half as long as the claws.

Lengths of leg joints.

[38 units=0.1 mm.]

Leg.	Joint.								
	Coxa.	Trochanter.	Femur.	Tibia.	Tarsus.				
					1st.	2d.	3d.	4th.	5th.
Fore	31	20	58	44	6	6	6	6	13
Middle	25	19	60	39	5	5	5	5	12
Hind	31	19	60	41	6	5	4	6	14

Habitat.—Rocky seashore on the tidal zone, Japan.

Holotype.—Alcoholic male; Seto, Wakayama Prefecture; August 23, 1930.

Allotopotype.—Alcoholic female; August 23, 1930.

Paratopotypes.—Males and female; August 23, 1930.

Type specimens.—Alcoholic and dry; deposited in the entomological laboratory, Kyoto Imperial University, the entomological laboratory, Kyushu Imperial University, and the British Museum; collected by M. Tokunaga.

This variety is closely similar to the type form, from which it differs only in the exceedingly long ultimate antennal joint and in the far smaller size.

Genus TELMATOGETON Schiner

TELMATOGETON JAPONICUS sp. nov.

This fly was found in association with various marine algæ, such as *Ulva* sp. and *Monostroma* sp., on rocky shore between the tide marks of the coasts of the Pacific Ocean and the Japan Sea. Immature forms were nesting among these algæ and imagines were running on or flying low over the rocky shore. Sometimes imagines were collected by a light screen ashore at night, and many larvæ were reared to the imaginal stage in a glass aquarium. Morphologically the immature forms closely resemble those of the other *Telmatogeton* species and *Paraclunio* species.

Male.—Body 2.9 to 4.3 mm in length, scantily haired; general coloration black; thorax very slightly pruinose; halters yellow; scutellum and legs brownish black; wings clouded entirely black.

Head round; vertex dark; clypeus brownish black, transversely large, with many black setæ; tormæ distinctly chitinized and quite smooth; postgenæ each with a black spot. Eyes bare, hemispherical, widely separated, distance between them subequal to the vertical length of the eyes. Antennæ (Plate 1, fig. 5)

black on the cephalic side and brown on the caudal side, very scantily haired but with many hyaline sensory hairs on the flagella, 7-segmented (excepting the narrow antennariæ); distal joint brown but its tip black, with one small apical seta and three long setæ on its proximal part, subequal in length to the preceding three or four joints taken together, antennaria very narrow and without setæ; scape very setigerous, subequal in length to the next joint and to the diameter of the scape itself; joints from second to sixth without setæ; second joint deeply constricted into two parts, proximal part without sensory hairs, while the distal part with many sensory hairs; following four joints moniliform, each shorter than the diameter of each joint. Maxillary palpi (Plate 1, fig. 6) brown on the dorsocephalic side and pale brown on the ventrocaudal side; 2-segmented; proximal joint black, spherical, with many black setæ; distal joint slender, half as wide as the proximal joint and four times as long as its own diameter, brown, with a few setæ on its distal half. Paraglossæ pale brown, very small, and with several minute setæ.

Pronotum separated into small, paired, lateral lobes, which are setigerous with several small setæ. Præscutum of the mesothorax very scantily haired, with three to four short setæ arranged along each of the pseudosutural foveæ; postscutum not distinctly bounded from præscutum, often with two small setæ on its caudomeson; supra-alar setal group represented by two to five small setæ; scutellum brown or blackish brown, very setigerous with black setæ.

Tip of the abdomen turned through 65° to 85° sinistrad, but rarely dextrad, between the seventh and ninth segments. Caudal two tergites of the abdomen reduced almost to membrane but the sternites chitinized and covered with minute setæ. Hypopygium (Plate 2, fig. 14) without long setæ, entirely covered with minute setæ, without secondary appendages. Coxites very large and stout, each with blunt projection on its dorso-proximo-mesal margin; styles small, folded inwards, without teeth or hooks, setæ on the mesal side curved and somewhat longer than those on the lateral side; anal tube large and prominent; tube of penis exposed between the coxites or caudad of the anal tube, guarded by a pair of slightly chitinized apophyses.

Legs stout and long, covered entirely with small setæ. Of the forelegs, coxæ large and femora somewhat clavate on the proximal part; tibiæ of the anterior four legs each with a single spur which is not curved but quite straight, spinous on its proximal half and subequal in length to the diameter of the tibia;

tibial spurs of the hind legs two on each leg, lateral spur slightly shorter than the mesal which is subequal in length to those of the other legs; tarsal joints each with a pair of small spines on its distoventral margin; third and fourth joints somewhat cordiform; ultimate joints of the legs all trilobated; median lobe very large, occupying about half the length of the fifth joint, covering the empodium; two lateral lobes unequal in size, the cephalic one is one-half, while the caudal one is one-fourth as large as the median lobe; empodium very large, pectinately plumose, extended as far as the median lobe; claws (Plate 2, fig. 16) asymmetrical, cephalic claw bifurcated into a long simple claw and a small spatulate comb, while the caudal claw is divided into a small simple claw and a large spatulate comb. Besides the above structures there are two prominent setæ, each of which is fully as long as the large claw, being located between the lobes and two elongated triangular lamellæ, which are fully as long as the median lobe; these lamellæ may be homologous with the pulvilli judging from their location.

Lengths of leg joints.

[50 units=1 mm.]

Sex and leg.	Joint.								
	Coxa.	Tro-chanter.	Femur.	Tibia.	Tarsus.				
					1st.	2d.	3d.	4th.	5th.
Male:									
Fore	20	9	71	67	35	14	8.0	7.0	11.0
Middle	15	8	105	81	33	12	7.0	6.0	11.0
Hind	16	9	102	85	40	20	7.5	6.0	10.0
Female:									
Fore	20	9	55	51	28	11	7.0	6.5	10.5
Middle	15	9	85	60	25	10	6.0	5.5	11.0
Hind	15	9	92	75	36	19	7.0	6.0	11.0

Wings (Plate 1, fig. 3) 2.1 to 4 mm in length, covered entirely with black microtrichiæ, brown under transmitted light, fringed with minute hairs; squama large, fringed with many small setæ; alula distinct; anal area well developed; anal angle distinctly developed and somewhat pointed. Cephalic veins black, caudal veins brown; veins R, R_1, and R_{4+5} strong, with several small setæ; distal tip of cell R_3 sharply pointed, R_{4+5} very long, longer than twice R_1 (56 : 24), ending a little before the wing tip or about on the same level with the tip of M_{1+2}, slightly curved along the costal margin; basal section of Rs very short

but wide; r-m oblique in position and very long; distal section of M (M_{1+2}) about one and one-half times as long as the proximal section of M (32 : 21), almost straight, very gradually curved caudal; M_{3+4} distinctly curved caudad, ending with a right angle on the caudal margin; fCu narrow, located just caudad of the proximal end of r-m; 1A sinuous, ending far beyond the base of fCu.

Female.—Closely resembling the male in structure and coloration of the head, thorax, legs, wings, etc., but different in the following points:

Body 3 to 4 mm in length. Ultimate segment of the abdomen thinly chitinized generally, conical, very scantily haired; setæ on the caudomesal part of the ultimate tergite somewhat longer than those on the other parts, cephalic margin of the same tergite thickly chitinized and black; telson, cerci, and ventral valves small, forming a conical common projection, ovipositor together; cerci (Plate 2, fig. 15) elongated caudad, as long as the ventral valves and about twice as long as the telson, setigerous entirely with minute setæ, each articulated with a thickened cercaria to the tip of the ultimate segment. Claws of the legs large, symmetrical, not serrated or furcated but quite simple; measurement of the legs as shown already. Wings comparatively broader than in the male, about 2.2 to 3 mm in length.

Habitat.—Seashore between the tide marks, Japan.

Holotype.—Male; Karo, Tottori Prefecture; July 4, 1931.

Allotopotype.—Female; July 3, 1931.

Paratypes.—Male and females; Karo, Tottori Prefecture; July 3 to 7, 1931; and Seto, Wakayama Prefecture; June 20, 1930.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University, the entomological laboratory, Kyushu Imperial University, and the British Museum; collected by M. Tokunaga.

This fly is allied to *Telmatogeton sancti-pauli* Schiner but differs distinctly in the venation, especially in the position of fCu, which is located far before the level of r-m in the allied species. The related Hawaiian torrential species, *T. abnorme* Terry, differing in the shape of the tarsal claws of the male; in the Japanese species the bifurcation of the claws is deeper than in the torrential species. Another species, recently reported by Edwards from Ancud, southern Chile, *T. trochanteratum* Edwards, is somewhat similar to the present species but easily distinguishable by the presence of the peculiar thumblike projection of the middle trochanter in the Chilian species.

ILLUSTRATIONS

[Drawings by M. Tokunaga.]

PLATE 1

FIG. 1. *Clunio setoensis* sp. nov., wing, male.
2. *Clunio tsushimensis* sp. nov., wing, male.
3. *Telmatogeton japonicus* sp. nov., wing, male.
4. *Clunio setoensis* sp. nov., antenna with antennaria, male.
5. *Telmatogeton japonicus* sp. nov., antenna with antennaria, male.
6. *Telmatogeton japonicus* sp. nov., maxillary palpus, male.
7. *Clunio tsushimensis* sp. nov., antenna with antennaria, male.
8. *Clunio tsushimensis* var. *minor* var. nov., antenna with antennaria, male.
9. *Clunio tsushimensis* var. *minor* var. nov., antenna without antennaria, female.

PLATE 2

FIG. 10. *Clunio setoensis* sp. nov., style, male, dorsal aspect.
11. *Clunio tsushimensis* sp. nov., style, male, dorsal aspect.
12. *Clunio tsushimensis* var. *minor* var. nov., cerci, female, dorsal aspect.
13. *Clunio tsushimensis* sp. nov., hypopygium, male, sternal aspect.
14. *Telmatogeton japonicus* sp. nov., hypopygium, male, tergal aspect.
15. *Telmatogeton japonicus* sp. nov., hypopygium, female, lateral aspect.
16. *Telmatogeton japonicus* sp. nov., tarsal claws of the left middle leg, male, ventral aspect.

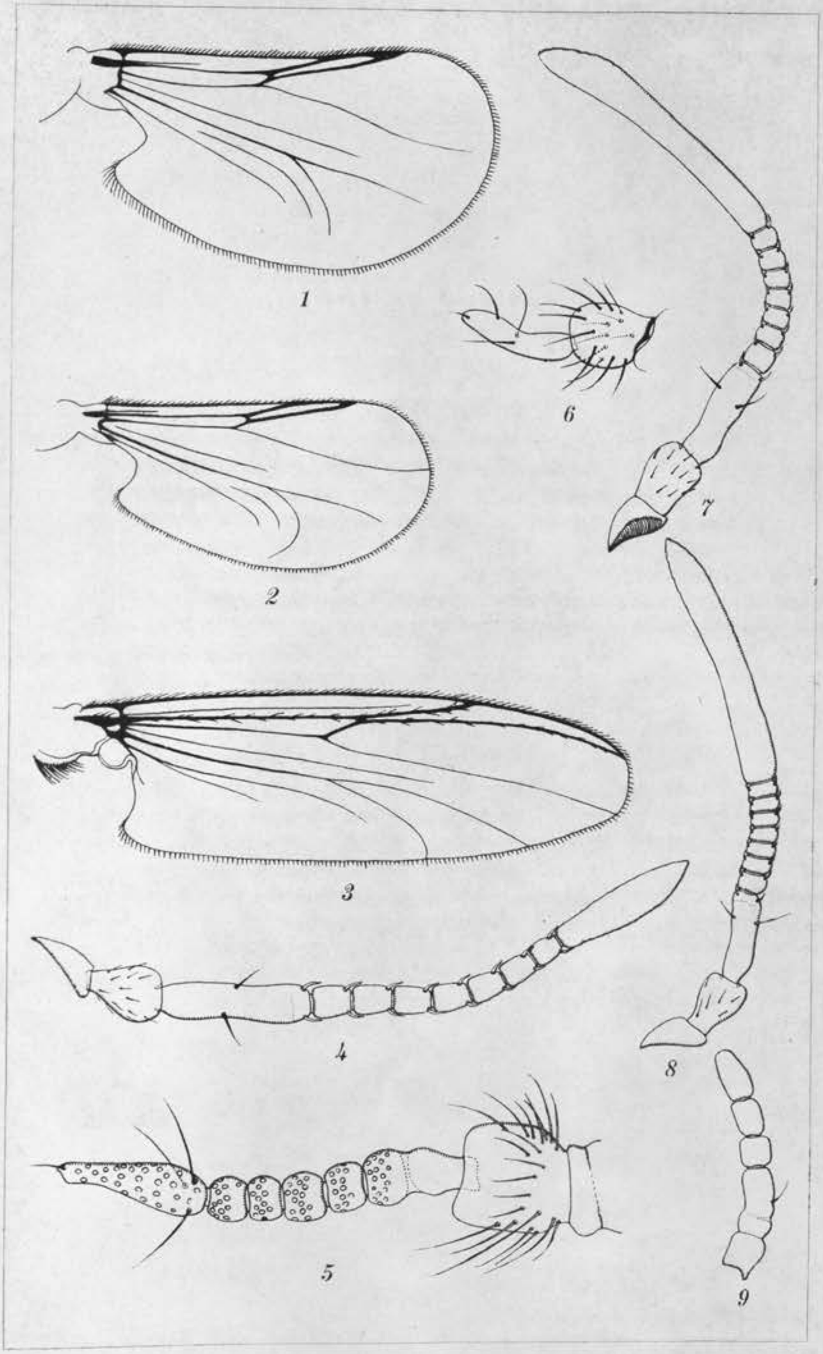
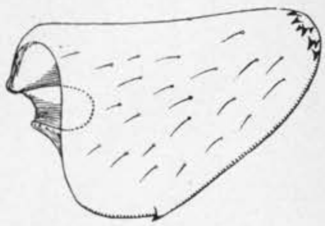


PLATE 1.



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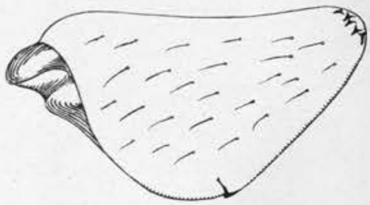

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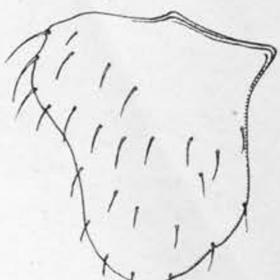

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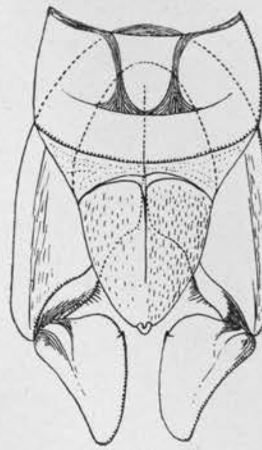

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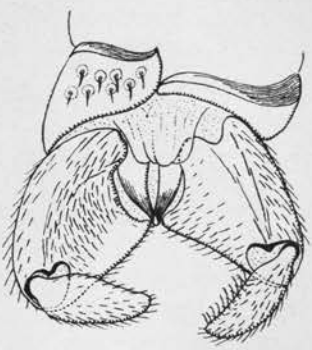

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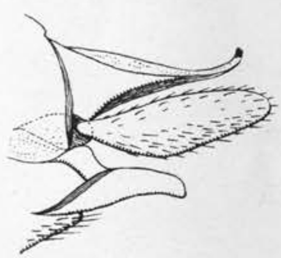

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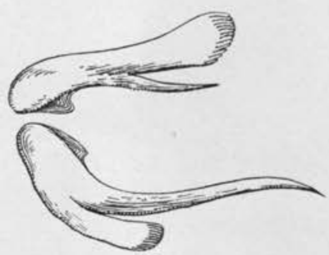

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PLATE 2.

NEW SCOLYTIDÆ FROM THE PHILIPPINES

By KARL E. SCHEDL

Of the Entomological Branch, Department of Agriculture, Ottawa, Canada

ONE PLATE

By the courtesy of Mr. F. C. Hadden, assistant entomologist for the Experiment Station of the Hawaiian Sugar Planters' Association, who was then temporarily residing at the Agricultural College, Laguna Province, Philippine Islands, I have been able to examine his collection of the families Scolytidæ and Platypidæ, all specimens of which were collected in the Philippine Islands or in Honolulu. I tender my thanks to Mr. Hadden for placing his collection at my disposition; descriptions of some of the new species and new localities for known forms are given in this paper.

XYLEBORUS HADDENI sp. nov.

Description of the female beetle.—Very shining, reddish brown, 2 mm long, twice as long as broad, glabrous except the anterior part of the pronotum and the sides of the elytra, which bear scattered hairs. Allied to *Xyleborus dossuarius* Egg., *quadrispinosulus* Egg., and *javanus* Egg.

Front plano-convex, minutely reticulate, with a few scattered punctures above the epistomal margin, pubescence scanty, except for a fringe along the epistomal margin. Eyes short oval, with a deep but narrow emargination in front. Antennæ yellowish, scape distinctly shorter than the funiculus and club united, second joint of the former distinctly longer than the following ones, club subcircular, truncate portion squamose, with one indistinctly visible suture.

Pronotum globose, 1.18 times wider than long, widest near the base, the latter truncate, posterolateral angles nearly rectangular, feebly rounded, sides uniformly rounded from the base to the apex, the apical margin extended and armed with six asperities, the two median of which are decidedly longer; summit

at the middle, anterior area rather coarsely asperate, posterior area minutely reticulate and with very fine, remotely placed punctures, median line hardly noticeable. Scutellum moderate in size, triangular.

Elytra as wide and 1.4 times as long as the pronotum, sides parallel, feebly arcuate, on the anterior three-fourths, apex distinctly angulate; disc ascending on the basal fourth, followed by a transverse impression like that in *dossuarius* Egg., declivity commencing slightly before the middle, oblique, hind margin and sides, up to the seventh interstice, acute, sharp; anterior fourth, before the transverse impression, irregularly punctured, shining, punctures not closely placed, transverse impression densely, rugulosely punctured, the sides coarsely remotely punctured with indications of rows; on the upper margin of the declivity the second and third interspaces widened, the second interspace armed with a small tuberclelike tooth, a decidedly larger tooth on the third interspace; while the former is near the posterior border of the transverse impression, the latter is already on the declivity face; declivity subshining, coarsely striate punctate, interstices flat, minutely, uniseriately punctate, the apical corner of the declivity elevated, suture feebly granulate at the extreme tip.

From its relatives this species is easily separated by its declivital armature. The sex has been determined by dissection of a paratype.

Holotype.—Female, Mount Maquiling, Laguna, Luzon, August 26, 1930, from branches of kalantas, *Toona calantas* Merr. and Rolfe; F. C. Hadden, collector.

Paratypes.—Six females with the same label; 4 from the same locality and host but collected, apparently, at another altitude.

XYLEBORUS DUPLICATUS sp. nov.

Description of the female beetle.—Pronotum black, elytra very dark brown, underside somewhat lighter, 4.3 mm long, twice as long as wide; allied to *X. hybridus* Egg.

Front plano-convex, strongly shining, with a smooth, feebly elevated median carina, just above the epistomal margin, between the eyes coarsely punctured and with scattered long hairs, a fringe of hairs also along the epistomal margin. Eyes short oval, emarginated in front. Antennæ reddish brown, scape shorter than the funiculus and club united, second segment of the funiculus very elongate, nearly as long as the remaining joints together, club slightly wider than long, truncate portion squamose, with indications of sutures.

Pronotum subquadrate, slightly wider than long (64:60), base and apex truncate, sides feebly arcuate, somewhat narrowed towards the apex, lateral angles subsimilarly rounded; summit high, behind the middle, anterior margin with no conspicuous asperities, anterior area steep, densely but rather finely asperate, posterior area minutely reticulate, with very fine and remotely placed punctures, median line not at all elevated, impunctate, a row of coarse punctures along the basal border; pubescence, which is restricted to the sides and the anterior area, scanty but long. Scutellum cordate, black and impunctate.

Elytra as wide and 1.68 times as long as the pronotum, base truncate, humeral angles rectangular, sides subparallel, slightly arcuate, on the anterior three-fourths, apically somewhat angulately rounded; ascending on the basal fourth, then uniformly rounded to the apex, basal fourth shining, apical portion subshining, opalescent, on the declivity suture feebly elevated, second interspace slightly impressed; distinctly striate-punctate throughout, punctures shallow but very closely placed, striæ impressed, slightly more on the declivity, interspaces flat, uniseriately punctate on the basal fourth, replaced by small tubercles on the apical three-fourths, apical margin acute. Anterior tibiæ widened distally with six small teeth on the outer edge beside the apical spur.

From *X. hybridus* this species is easily distinguished by the size, less-flattened declivity, shape of the pronotum, and the opalescent apical portion of the elytra.

Holotype.—Female, Mount Maquiling, Laguna, Luzon, June 11, 1931, from tibig, *Ficus nota* (Blanco) Merr., and balobo, *Diplodiscus paniculatus* Turcz.; F. C. Hadden, collector.

Paratypes.—Many females, with the same label.

XYLEBORUS NEPOS Egg. var. ROBUSTUS var. nov.

Eight specimens, which were taken on Mount Maquiling, Laguna, Luzon, July 16 and 26, 1930, by F. C. Hadden, correspond with the original description of *X. nepos* Egg., but show the following differences:

The pronotum is distinctly wider than long, the apical margin of the elytra is rather acute, and the form is even a little stouter than in *X. interjectus* Blandf. and not slenderer than *interjectus* as *nepos* should be according the description of Eggers.

XYLEBORUS INDICUS Eichh.

Two specimens with the label Mount Maquiling, Laguna, Luzon, August 19, 1930, 400 feet elevation, from white nato,

Sideroxylon macranthum Merr., F. C. Hadden, collector, agree perfectly with Eichhoff's description. A third specimen, with the same label, seems to be the hitherto undescribed male.

Description of the male beetle.—Yellowish brown, depressed, 1.83 mm long, 2.77 times as long as wide.

Front plano-convex, finely reticulate, with few distinct punctures.

Pronotum semielliptical, longer than wide (26:23), slightly convex, applanate towards the apex, the latter unarmed, finely asperate in front, rather densely hairy; polished and finely punctured behind.

Elytra as wide and 1.8 times as long as the pronotum, sides parallel on the anterior four-fifths, rather angulately rounded behind, with a very small emargination at the tip of the apex; subcylindrical on more than the basal half, then obliquely declivous; striate throughout, striæ not at all impressed on the disc, distinctly so on the declivity, interspaces impunctate on the disc, convex and finely tuberculate on the declivity, apical margin acute.

The base of the pronotum is distinctly but shallowly emarginate; the anterior tibiæ slender, narrow, very finely dentate on the outer edge.

COCCOTRYPES PHILIPPINENSIS sp. nov.

Description of the adult female.—Bright reddish brown, 1.95 mm long, 2.25 times as long as wide, allied to *C. uniseriatus* Egg.

Front plano-convex, longitudinally aciculate, with slight indications of a smooth median carina, rather rugulosely punctured and with interspersed hairs. Eyes large, broadly oval, slightly emarginate in front. The antennæ are remarkable in as much as the club is 1.36 times as wide as long.

Pronotum 1.12 times as wide as long, widest behind the middle, base truncate, posterolateral angles moderately rounded, sides subparallel on the basal third, feebly constricted towards the base, rather strongly constricted towards the apex, obtusely rounded in front; apical margin unarmed, surface rather feebly convex, asperate and sparsely hairy over the entire surface, with no indications of concentric arrangement, median line indistinct, sides subacute. Scutellum small, triangular, smooth.

Elytra distinctly wider (32:29) and 1.76 times as long as the pronotum, sides parallel on more than the basal half, then somewhat constricted, slightly angulately rounded behind; cylin-

drical on more than the anterior half, declivity evenly convex, feebly applanate; strial punctures coarse, in regular rows, moderately closely placed, hardly impressed on the disc, distinctly so on the declivity, especially the sutural striæ, the strial punctures bear no setæ, interspaces as wide as the diameter of the strial punctures, very feebly rugose near the base, uniseriately punctured on the disc, towards the declivity these punctures become minute tubercles, all interstrial punctures and tubercles bear long, erect setæ, the interstrial punctures are more remotely placed, distance from one to the other about one and one-half times the diameter of one strial puncture; suture slightly elevated towards the apex of the declivity.

I am inclined to place this species close to *C. uniseriatus* Egg. The latter can be separated from *philippinensis* by the shape of the pronotum, the size, the proportions of the elytra, and the punctuation.

Holotype.—Female, Mount Maquiling, Laguna, Luzon, August 16, 1930, from seeds of malaruhat-puti, *Eugenia similis* Merr.; F. C. Hadden, collector.

Paratypes.—Many, with the same label.

RECORDS OF DESCRIBED SPECIES

PLATYPUS SETACEUS Chap.

Mount Maquiling, Laguna, Luzon, Philippine Islands, July 11, 1931, from balobo; F. C. Hadden, collector.

PLATYPUS SOLIDUS Walk var. EXILIS Chap.

Same locality and collector, July 16 and 30, August 6, and December 26, 1930; March 3, 1931.

PLATYPUS JANSONI Chap.

Same locality and collector, June 26, July 16 and 19, October 1 and 27, 1930.

CROSSOTARSUS FRAGMENTUS Samps.

Same locality and collector, one specimen, July 16, 1930.

CROSSOTARSUS LECONTEI Chap.

Same locality and collector, June 11, 1931, from *Sideroxylon macranthum*.

XYLEBORUS SEXSPINOSUS Motsch.

Same locality and collector, July 26, 1930, from *Toona calantas*.

XYLEBORUS HYBRIDUS Egg.

Same collector and locality, August 16, 1930, June 11, 1931.

XYLEBORUS DOSSUARIUS Egg.

Same locality and collector, August 26, 1930, from *Toona calantas.*

XYLEBORUS EXIGUUS Walk.

Same locality and collector, September 29, 1930, from *Toona calantas.*

XYLEBORUS SIMILIS Ferr.

Same locality and collector, August 16 and 19, 1930, from *Sideroxylon macranthum.*

COCCOTRYPES DACTYLIPERDA Fabr.

Honolulu, Hawaii, July 9, 1926, from *Persea gratissima* Gaertn.

ILLUSTRATION

PLATE 1

FIG. 1. *Xyleborus haddeni* sp. nov.
2. *Xyleborus haddeni* sp. nov.
3. *Xyleborus duplicatus* sp. nov.
4. *Coccotrypes philippinensis* sp. nov.
5. *Xyleborus nepos* var. *robustus* var. nov.
6. *Xyleborus duplicatus* sp. nov.
7. *Xyleborus haddeni* sp. nov.
8. *Coccotrypes philippinensis* sp. nov.

NEU BEKANNT GEWORDENE RHYNCHITINEN UND ATTELABINEN DER ORIENTALISCHEN REGION (COLEOPTERA; CURCULIONIDÆ)

40. BEITRAG ZUR KENNTNIS DER CURCULIONIDEN

Von EDUARD VOSS

Berlin-Charlottenburg, Deutschland

RHYNCHITES (INVOLVULUS) EGENUS sp. nov.

Kopf quer, ziemlich kräftig und sehr dicht punktiert; Augen ziemlich kräftig vorgewölbt, wenig länger als die Stirn breit und diese so breit wie der Rüssel vor der Basis. Rüssel etwa so lang wie das Halsschild, kräftig und gleichmässig gebogen; basale Hälfte mit feinem Mittelkiel, der sich an der Fühlereinlenkung gabelt und seitlich von je einer Längsfurche begleitet wird. Fühler in der Mitte des Rüssels eingelenkt. Schaft- und 1. Geisselglied gleichlang, jedes fast doppelt so lang wie breit; 2. bis 4. Glied etwas kürzer; 5. und 6. Glied noch länger als breit; 7. Glied quer. Glieder der Keule erheblich länger als breit. Halsschild breiter als lang, seitlich ziemlich kräftig gerundet, zum Vorderrand mehr als zur Basis verschmälert; ziemlich kräftig und sehr dicht punktiert, mit feiner Mittelfurche. Schildchen quer, viereckig; fein und sehr dicht punktiert. Flügeldecken etwa anderthalbmal so lang wie breit, im basalen Teil parallelseitig, dann leicht gerundet verbreitert. Punktstreifen mässig stark, hinten etwas feiner, die Punkte schmal getrennt; Zwischenräume flach, breiter als die Streifen, sehr dicht unregelmässig punktiert, die Punkte ziemlich kräftig, doch feiner als diejenigen der Streifen. Pygidium in gleicher Weise wie die Zwischenräume der Flügeldecken punktiert. Tibien kräftig, gerade.

Färbung stahlblau; Rüssel, Fühler, Tibien und Tarsen schwarz, Schultern grün, Rüssel mit Erzglanz. Behaarung wenig dicht, doppelt: kürzer, nach hinten gerichtet, etwas langer, abstehend. Länge 5.5 mm.

CHINA, Hangchow (*Tsai*), April, 1930. In meiner Sammlung.

Den Arten der Untergattung *Haplorhynchites*, etwa dem *R. pubescens* F. ähnlich, doch vereinigt sich der vorletzte Punktstreif mit dem Randstreif vor der Mitte der Decken. Von dieser und der folgenden Art verdanke ich der Liebenswürdigkeit von Herrn Prof. Tsai das typische Exemplar, für die zu danken ich auch an dieser Stelle Gelegenheit nehmen möchte.

RHYNCHITES (RHYNCHITES) CONFRAGOSICOLLIS sp. nov.

Männchen.—Kopf breiter als lang, schwach konisch, kräftig und sehr dicht punktiert, die Stirn mit breiter, durch kurze Kiele begrenzte Furche. Augen schwach gewölbt, so lang wie die Stirn breit, diese schmaler als der Rüssel an der Basis dick. Rüssel kaum so lang wie Kopf und Halsschild zusammen, schwach gebogen, ziemlich kräftig und sehr dicht runzlig punktiert, Basalhälfte mit schwachem Mittelkiel. Fühler mittenständig; Schaft- und 1. Geisselglied gleichlang, jedes etwa anderthalbmal so lang wie breit; 2. bis 4. Glied etwas länger; 5. Glied wenig länger als breit; 6. Glied so lang wie breit; 7. Glied quer. Erstes Glied der Fühlerkeule länger als breit; 2. und 3. Glied so lang wie breit; Endglied zugespitzt. Halsschild breiter als lang, seitlich mässig stark gerundet, die grösste Breite liegt hinter der Mitte, zum Vorderrand mehr verschmälert als zur Basis und an demselben leicht eingeschnürt; hinter der Mitte oberseits mit breiterem V-förmigen Eindruck. Punktierung kräftig und sehr dicht. Schildchen trapezförmig. Flügeldecken etwa anderthalbmal so lang wie breit; von den Schultern ab kurz parallelseitig, dann schwach gerundet verbreitert. Punktstreifen mässig stark, die Punkte durch schmale Querrunzeln getrennt; Punktierung der Zwischenräume wenig schwächer, sehr dicht unregelmässig. Unterseite fein und sehr dicht punktiert. Tibien schlank und gerade.

Färbung grünmetallisch, stellenweise mit schwachem Kupferschein; Fühler schwarz. Behaarung mässig dicht, länger abstehend, greis. Länge 5.5 mm.

CHINA, Hangchow (*Tsai*), 7. Mai, 1930. In meiner Sammlung.

Eine Art aus der näheren Verwandtschaft des *R. bacchus* L. und dem *R. faldermanni* Boh. am nächsten stehend. Die Männchen beider Arten haben im Gegensatz zu *bacchus* einen etwas längeren, spitzen Seitendorn am Halsschild, flacher gewölbte und mehr seitlich stehende Augen. Unsere Art unterscheidet sich von *faldermanni* durch kürzeren Rüssel, flachere Augen, etwas schmalere Stirn, seitlich weniger gerundetes Halsschild

und etwas kräftigere Punktierung. *Rhynchites faldermanni* ist in der Regel purpurrot übergossen.

BYCTISCUS (TAIWANOBYCTISCUS) COMPLANATUS sp. nov.

Männchen.—Kopf mässig stark und sehr dicht, auf der Stirn längsrunzlig punktiert; Stirn schmaler als der Rüssel vor der Basis. Rüssel kräftig, nicht ganz so lang wie das Halsschild, oberseits vor der Fühlereinlenkung mit muldenförmiger Vertiefung; im basalen Teil auf dem Rücken glänzend, fein und wenig dicht punktiert. Fühler mittenständig. Schaftglied so lang wie breit; 1. Geisselglied etwas länger als das Schaftglied; 2. Glied kurz, wenig länger als breit und gut halb so lang wie das 1. Glied; 3. Glied etwas länger als das 1. Glied; 4. Glied kaum länger als das 2. Glied; 5. Glied kugelförmig; 6. und 7. Glied breiter als lang; 1. und 2. Glied fast so lang wie breit; 3. Glied mit dem Endglied so lang wie das 1. und 2. Glied zusammen. Halsschild breiter als lang, seitlich stark gerundet. Mitte mit schmaler punktfreier Mittelfurche; Punktierung mässig stark und sehr dicht. Schildchen quer, viereckig, fein und sehr dicht punktiert. Flügeldecken parallelseitig, etwa ein und ein Viertelmal so lang wie breit. Punktstreifen ziemlich kräftig, Punkte einzeln eingestochen, nicht furchig vertieft, schmal getrennt; Zwischenräume durchaus flach, die inneren sechs Zwischenräume viel breiter als die Streifen, sehr fein und mässig dicht, im Eindruck hinter dem Schildchen etwas kräftiger punktiert. Der vorletzte Punktstreif vereinigt sich mit dem Randstreif in der Höhe des 2. Abdominalsegments.—Pygidium kräftig und sehr dicht punktiert, ebenso auch Mittel und Hinterbrust mit Seitenteilen, das Abdomen dagegen feiner und weitläufiger.

Weibchen.—Halsschild viel feiner und weniger dicht punktiert.

Färbung stahlblau; Fühler, Tibien und Tarsen schwarz. Länge 5.5 mm.

CHINA, Shanhaikwan, in den Bergen (*Thomson*), September, 1906. British Museum (Natural History); in meiner Sammlung.

LISTROBYCTISCUS SULÆNSIS sp. nov.

Männchen.—Kopf sehr fein und dicht punktiert; Stirn schmaler als der Rüssel. Letzterer kräftig, so lang wie Kopf und Halsschild zusammen, mässig stark und sehr dicht punktiert, schwach gebogen, parallelseitig, an der Spitze schwach verbreitert, mit basalem Mittelkiel, begrenzt von seitlicher Längsfurche.

Fühler vor der Rüsselmitte eingelenkt. Schaft- und 1. Geisselglied gleichlang, anderthalbmal so lang wie breit; 2. bis. 4. Glied von gleicher Länge, etwas kürzer als das 1. Glied die restlichen Glieder so lang wie briet, zur Spitze allmählich an Stärke zunehmend. Erstes und 2. Glied der Fühlerkeule quer, 3. Glied mit dem Endglied so lang wie das 1. und 2. Glied zusammen. Halsschild so lang wie breit, seitlich mässig stark gerundet, die grösste Breite liegt hinter der Mitte, kurz vor dem basalen Drittel; Punktierung sehr fein und dicht. Die seitliche Bewehrung ziemlich kräftig. Schildchen quer, viereckig. Flügeldecken von den Schultern ab schwach geradlinig zur Mitte verbreitert, dann gerundet verschmälert. Punktstreifen vorn mässig stark, hinten sehr fein; Zwischenräume im basalen Teil fein und wenig dicht, undeutlich punktiert. Pygidium fein und dicht punktiert.

Färbung schwarz. Länge 3.6 mm.

SULA INSELN (*Wallace*). British Museum (Natural History).

In der Gruppe der *Listrobyctiscus*-Arten mit beim Männchen bewehrtem Halsschild hat diese Art mit dem *L. patruelis* m. von Formosa das zur Basis verschmälerte Halsschild gemeinsam und unterscheidet sich dadurch von allen übrigen Verwandten dieser Gruppe.

Eine weitere zur Gattung *Listrobyctiscus* gehörige Art ist der mir bislang unbekannt gebliebene—

LISTROBYCTISCUS ÆSTUANS (Pascoe).

Rhynchites æstuans PASCOE, Ann. & Mag. Nat. Hist. IV 15 (1875) 392.

Rüssel verhältnismässig kräftig, schwach gebogen, oberseits an der Basis ohne Mittelkiel und Furchen. Fühler mittenständig. Schaft- und 1. Geisselglied gleichlang, zusammen so lang wie der Rüssel an der Einlenkungsstelle dick; alle folgenden Glieder an Länge allmählich abnehmend. Glied 1 und 2 der Fühlerkeule so lang wie breit, das 3. Glied mit dem Endglied etwa drei Viertelmal so lang wie die 1. und 2. Glieder zusammen. Halsschild so lang wie breit, schwach konisch, wenig gerundet, nicht erkennbar punktiert. Flügeldecken von den Schultern ab gerundet zur Mitte verbreitert. Punktstreifen vorn ziemlich kräftig, nicht furchig vertieft, sondern die Punkte einzeln eingestochen, nach hinten zu feiner werdend, aber durch die Decken von der Unterseite in gleicher Stärke wie vorn durchscheinend.

Färbung bräunlichrot; Tarsen etwas angedunkelt. Länge 3.6 mm.

NORDOST-CELEBES, Menado (*Wallace*). British Museum (Natural History).

An dem einzigen mir vorliegenden Exemplar lässt sich das Geschlecht nicht feststellen, es scheint aber, als ob es sich um ein Männchen handelt und die Art damit der 1. Gruppe der Gattung mit beim Männchen unbewehrtem Halsschild zugehören würde. Die Tibien sind an der Spitze etwas verbreitert und leicht muldenförmig vertieft.

Bemerkenswert ist diese Art, weil es die einzige bisher bekannt geworden Art mit rotgelber Färbung in der Tribus Byctiscini ist.

PARAMECOLABUS (CATALABUS) ELEGANS sp. nov.

Männchen.—Kopf sehr fein zerstreut punktiert, Schläfen zylindrisch und der Kopf hinter den Augen fast so lang wie breit. Augen stark halbkugelförmig vorgewölbt, die Stirn schmaler als der Augenlängsdurchmesser, beiderseits mit einer Längsfurche, die sich seitlich auf dem Rüssel fortsetzt. Rüssel anderthalbmal so lang wie breit, von der Basis geradlinig nach vorn verbreitert, fein und dicht punktiert. Fühler im basalen Drittel des Rüssels eingelenkt. Schaftglied etwas länger als breit; 1. Geisselglied kugelförmig; 2. und 3. Glied verkehrt Gegelfömig, so lang wie das 1. Glied; die übrigen Glieder quer. Erster und 2. Glied der Fühlerkeule quer, das 3. Glied länger als den 1. und 2. Gliedern zusammen. Halsschild quer; seitlich kräftig geradlinig konisch nach vorn verjüngt, hinten schwielenförmig verrundet und der Postsegmentalring akut abgesetzt; Præsegmentalring durch scharfen Eindruck oberseits vom Scutum abgesetzt, letzteres beiderseits der Mitte mit je zwei in gleicher Höhe liegenden flachen Gruben. Punktierung undeutlich. Schildchen trapezförmig. Flügeldecken anderthalbmal so lang wie breit, parallelseitig. Punktstreifen mässig stark, die Punkte einzeln stehend; Zwischenräume flach, breiter als die Streifen, nicht erkennbar punktiert. Pygidium fein und mässig dicht punktiert. Vorderschenkel kräftig gekeult, viel stärker und länger als die übrigen; Vordertibien im apikalen Teil stark einwärts gebogen. Schenkel vor der Spitze mit kurzem, spitzem Zahn.

Weibchen.—Schläfen kürzer; Vordertibien kürzer und an der Spitze weniger scharf einwärts gebogen.

Färbung schwarz, Kopf und Halsschild erzglänzend; Flügeldecken rot. Länge 6 mm.

INDIEN, United Provinces, Kumaon, Nainital Div. (*H. G. Champion*). British Museum (Natural History); in meiner Sammlung.

Dem *P. simulatus* Mshl. am nächsten stehend und ihm sehr ähnlich, doch folgendermassen zu unterscheiden: Augen mehr vorgewölbt, die seitliche basale Schwiele des Halsschilds weniger exponiert, das Halsschild dadurch weniger konisch erscheinend; die Färbung des Abdomens mit dem übrigen Körper gleichfarbig schwarz, erzglänzend und das Tier im ganzen kleiner.

EUOPS (EUOPS) TONKINENSIS sp. nov.

Weibchen.—Kopf konisch, ohne Quereindruck, sehr fein zerstreut punktiert; Augen seitlich aus der Kopfwölbung nicht vorragend. Rüssel glänzend und unpunktiert, etwa doppelt so lang wie breit, von der Basis geradlinig nach vorn verbreitert. Fühler kurz vor der Rüsselbasis eingelenkt. Schaft- und 1. Geisselglied kräftig, etwas länger als breit; 2. und 3. Glied kaum kürzer als das 1. Glied; 4. und 5. Glied wenig kürzer als das 2. und 3. Glied; 6. und 7. Glied kaum so lang wie breit; 1. und 2. Glied der Fühlerkeule so lang wie breit; 3. Glied am längsten. Halsschild quer, stark konisch, am Vorderrand kaum halb so breit wie an der Basis, seitlich nur wenig gerundet; oberseits mässig stark und wenig dicht punktiert, seitlich kräftiger und dichter. Schildchen viereckig, so lang wie breit. Flügeldecken wenig länger als breit, schwach geradlinig nach hinten zu verschmälert; Zwischenräume viel breiter als die Streifen, kaum gewölbt, mässig stark einreihig punktiert. Hinterbrust mässig stark und sehr dicht punktiert, die vorderen Abdominalsegmente fein und weitläufig, die hinteren gedrängter punktiert. Pygidium fein und sehr dicht punktiert. Vordertibien gedrungen und breit, an der Spitze einwärts gebogen, die Mittel- und Hintertibien im ganzen nicht gebogen.

Färbung dunkelblau; Flügeldecken glänzend purpurrot, die Naht blau; Beine pechbraun. Länge 2.8 mm.

CHINA, Tonkin, Montes Mauson, 2,000 bis 3,000 Fuss Höhe (*Fruhstorfer*). Mus. Berlin (Coll. Moser); in meiner Sammlung.

Diese Art ist *Euops ignita* m. aus Birma sehr nahe verwandt. Während diese aber glänzende, unpunktierte Zwischenräume der Punktstreifen auf den Flügeldecken besitzt, hat unsere Art ziemlich kräftig punktierte Zwischenräume, die auch leicht gewölbt erscheinen; das Halsschild ist oben fein und dicht, seitlich sehr

dicht punktiert und auch das Abdomen weist eine kräftigere und dichtere, hinten sehr dichte Punktierung auf, auch ist *tonkinensis* grösser. *Euops gardneri* Mshl., Ind. Forest Rec. 16 (8) (1931) 263, scheint ebenfalls dieser Art sehr nahe zu stehen, aber ein weniger konisches Halsschild zu besitzen und *Euops fulgida* Faust ist ausser durch die gerundetere Form durch mehr gewölbt Zwischenräume auf den Flügeldecken zu trennen.

EUOPS (EUOPS) INSULARIS sp. nov.

Männchen.—Kopf glänzend, unpunktiert, hinter den Augen mit tiefer Einschnürung. Rüssel gut anderthalbmal so lang wie breit, in der basalen Hälfte schmal, parallelseitig, dann von der Mitte ab bis zur doppelten Breite der Basis nach vorn verbreitert, unpunktiert; von der Seite gesehen kräftig gebogen. Fühler kurz vor der Russelbasis eingelenkt. Schaftglied etwa anderthalbmal so lang wie breit; 1. Geisselglied etwas länger als breit; 2. bis 5. Glied so lang wie das 1. Glied; 6. Glied so lang wie breit; 7. Glied quer. Erstes Glied der Fühlerkeule etwas länger als breit; 2. Glied breiter als lang; 3. Glied mit dem Endglied etwas länger als das 1. Glied. Halsschild breiter als lang, die grösste Breite liegt in der Mitte, von hier nach hinten nur wenig verschmälert, nach vorn dagegen stark gerundet verengt, am Vorderrand kurz kragenförmig abgesetzt; oben glänzend, unpunktiert, seitlich ziemlich kräftig und sehr dicht punktiert. Schildchen breiter als lang, hinten konvex gerundet. Flügeldecken etwa ein und ein Viertelmal so lang wie breit, hinter den Schultern etwas eingezogen, dann gleichmässig schwach gerundet nach hinten verschmälert. Punktstreifen mässig stark, nach hinten zu feiner werdend; Zwischenräume wenig schmaler als die Streifen, unpunktiert. Hinterbrust mässig stark und sehr dicht punktiert, Abdomen fein und weitläufig, nur das letzte Segment dichter punktiert. Pygidium fein und dicht punktiert. Vordertibien schlank, gleichmässig gebogen; Mitteltibien zur Spitze keilförmig verbreitert, Hintertibien in der apikalen Häfte leicht einwärts gebogen.

Weibchen.—Augen kleiner, weniger vorstehend; Kopf hinter den Augen nicht abgeschnürt. Halsschild von der Basis ab fast halbkugelförmig verrundet. Mitteltibien an der Spitze nach innen spitz vorgezogen; Vordertibien nur im apikalen Drittel leicht gebogen.

Färbung schwarz, glänzend; Schildchen (Månnchen) grün; Fühler rot. Långe 2.5 mm.

ARU-INSELN. KEY-INSELN. Mus. Berlin (Coll. Moser); in meiner Sammlung.

Die Art ähnelt sehr *Euops nigra* m. von Australien, hat jedoch ein mehr verrundetes Halsschild, stärkere Punktstreifen und indere Kopfform, auch sind die Tibien anders gebildet.

EUOPS (EUOPS) SANDAKANENSIS sp. nov.

Weibchen.—Kopf glänzend und nur mit vereinzelten sehr feinen Punktchen versehen, auch der Rüssel glänzend und kaum erkennbar punktiert. Fühler an der Rüsselbasis eingelenkt. Schaft- und 1. Geisselglied gleichlang, kräftig, wenig länger als breit; die nächsten Glieder schwächer, das 2. bis 5. Glied jedoch noch länger als breit. Die Glieder der Fühlerkeule breiter als lang. Halsschild breiter als lang, kräftig konisch, seitlich geradlinig; obserseits sehr fein und weitläufig punktiert, seitlich etwas kräftiger und dichter. Schildchen so lang wie breit, hinten zugespitzt, unpunktiert. Flügeldecken wenig länger als breit, seitlich schwach gerundet. Punktstreifen besonders vorn sehr kräftig; Zwischenräume schmal, glänzend, unpunktiert, nach innen schräg abfallend. Mittelbrust fein chagriniert, mit einzelnen kräftigen Punktgruben; Hinterbrust sehr kräftig und sehr dicht punktiert, Abdomen sehr fein und wenig dicht punktiert, Pygidium fein und dicht punktiert. Vordertibien aussen schwach gebogen, kurz, in der Mitte innen stark verbreitert; Hintertibien schlank und gerade.

Färbung schwarz, glänzend. Länge 2.4 mm.

BORNEO, Sandakan (*Baker, 17122*). In meiner Sammlung; United States National Museum.

Diese Art steht in der Nähe von *Euops maculata* m., von den verwandten Arten durch die kräftigen Punktstreifen zu trennen.

EUOPS (SYNAPTOPS) KHARSU sp. nov.

Männchen.—Augen gross, kräftig, gewölbt. Rüssel so lang wie breit, von der Basis nach vorn kräftig verbreitert, gerade, abwärts gerichtet, fein und dicht punktiert. Fühler basal eingelenkt. Schaftglied kräftig, keulenförmig; 1. Gleisselglied kurz oval, von gleicher Stärke wie das Schaftglied, die nächsten Glieder viel schwächer; 2., 3. und 5. Glied länger als breit, etwas kürzer als das 1. Glied; 4. Glied wenig länger als breit; 6. und 7. Glied so lang wie breit. Erstes Glied der Fühlerkeule etwas länger als breit; 2. und 3. Glied etwas breiter als lang, das Endglied kurz, zugespitzt. Halsschild breiter als lang, konisch, seitlich leicht gerundet, zum Vorderrand wenig mehr zugerundet, vor

dem Hinterrand mit subbasaler Querfurche; die Querriefen kräftig und dicht, die Punkte in denselben mässig deutlich. Flügeldecken etwa anderthalbmal so lang wie breit, parallelseitig; Punktstreifen mässig stark; Zwischenräume flach, etwas breiter als die Streifen, fein und dicht versetzt zweireihig punktiert. Pygidium fein und dicht punktiert; Abdomen seitlich etwas dichter, Mittel- und Hinterbrust mit Seitenteilen kräftig und sehr dicht punktiert. Vordertibien aussen nur leicht gebogen, innen seicht s-förmig geschweift; Tarsen schlank und dünn.

Weibchen.—Die drei ersten Abdominalsegmente mit je einer Doppelreihe Querbürsten, das 4. Segment mit einer einfachen Querbürste; die Vordertibien etwas kürzer als beim Männchen sonst in der Form aber kaum abweichend.

Färbung metallischgrün, bisweilen mit kupfernem Schein. Länge 2.8 bis 3 mm.

INDIEN, United Provinces, Garhwal, Dudhatoli, in 9,000 Fuss Höhe (*H. G. Champion*), Juni 1920; Süd-Garhwal, Kumaon, in 6,500 Fuss Höhe. British Museum (Natural History); in meiner Sammlung.

Die Art wurde auf Beate kharsu gefunden. Sie ist leicht kenntlich an den seitlich stark gewölbten Augen, die in der grossten Gesamtbreite breiter als der Vorderrand des Halsschilds sind, sowie an den parallelseitigen Flügeldecken. Systematisch steht die Art zwischen *Euops nietneri* Jekel un *bakewelli* Jekel.

EUOPS (CHAROPS) ARMIPES sp. nov.

Augen mässig stark vorgewölbt, Gesamtbreite schmaler als der Vorderrand des Halsschilds. Rüssel kurz, breiter als lang, von der Basis zur Spitze stark verbreitert. Fühler basal eingelenkt; Schaftglied gut anderthalbmal so lang wie breit; 1. Geisselglied kugelförmig; die folgenden Glieder viel schwächer, länger als breit, untereinander in der Länge wenig verschieden; Glieder der Fühlerkeule breiter als lang. Halsschild fast so lang wie breit, seitlich ziemlich kräftig gerundet, die grosste Breite liegt hinter der Mitte; oben kräftig querriefig skulptiert, seitlich stark und sehr dicht runzlig punktiert. Flügeldecken etwas länger als breit, hinter den Schultern leicht eingezogen, dann schwach geradlinig nach hinten verschmälert. Punktstreifen kräftig, nach hinten zu feiner werdend; Zwischenräume nur schmal, leicht gewölbt. Abdomen fein und dicht punktiert, Mittel- und Hinterbrust mit Seitenteilen kräftiger und sehr dicht punktiert. Mitteltibien vor der Spitze aussen mit langem, spitzem, kräftigem Dorn bewehrt.

Färbung schwarz, oben erzglänzend. Länge 2.2 mm.

INDIEN, Lachiwala, Dehra Dun (*H. G. Champion*). British Museum (Natural History).

APODERUS (STRIGAPODERUS) SISSU Mshl.

Apoderus sissu Mshl. ist eine dem *A. picinus* Faust nahe verwandte Art, mit welcher sie den abgeschnürten und aufgeworfenen Halsschildvorderrand gemeinsam hat, von welcher sie jedoch durch folgende Merkmale leicht zu unterscheiden ist: erstens ist der Kopf glänzend und nicht wie bei *picinus* querriefig skulptiert; zweitens sind die Zwischenräume der Punktstreifen auf den Flügeldecken schmaler, mehr gewölbt, glänzender und nicht runzling skulptiert.

Bei der Nominatform sind alle Makeln scharf gezeichnet, bisweilen verbinden sie sich jedoch untereinander und formieren sich zu Querbinden: (*confluens* f. n.), wobei gleichzeitig eine Schwärzung der Mittel- und Hinterbrust, der Seiten des Kopfes und Halsschilds und zuweilen der Spitzen der Tibien und der Tarsen eintritt. Die Flügeldecken können auch mit Ausnahme der Umrandung des Schildchens und her Spitzen der Flügeldecken einfarbig schwarz gefärbt sein, (*modesta* f. n.), oder im Gegensatz dazu das ganze Tier einfarbig rotgelb sein mit Ausnahme von je einer kleinen runden Makel auf der Mitte des 4. Punktstreifens, (*bipunctulata* f. n.).

INDIEN, Kumaon, Haldwani District (*H. G. Champion*), August, 1921. British Museum (Natural History); in meiner Sammlung.